IMPROVING COGNITIVE INDEPENDENCE OF DEMENTIA PATIENTS USING MACHINE LEARNING ENABLED MOBILE APPLICATION

Project Id: 2023-081

Final Report

B.Sc. (Hons) Degree in Information Technology

(Specialization in Software Engineering)

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology

Sri Lanka

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The dissertation was submitted in partial fulfilment of the requirements
for the B.Sc. Special Honors degree in Information Technology (Specialization in Software Engineering)

Department of Computer Science and Software Engineering
Sri Lanka Institute of Information Technology
Sri Lanka

September 2023

DECLARATION

We declare that this is our own work, and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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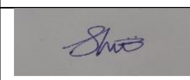
Jayasinghe J.M.S.U.	IT20034740	
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ABSTRACT

Dementia is a common cognitive impairment that can be identified in society. The affected patients struggle to maintain their independence because most of the patients are looked after by caregivers. This research presents a solution for mild and moderate dementia patients to improve their cognitive independence by focusing on their thinking patterns, memory, behavior, and ability to perform everyday activities. The proposed system provides a location tracking mechanism that can define safe zones and predict locations which helps in monitoring patients' wandering behavior. The system includes a digital audio diary that keeps daily records of patients which helps to maintain the stability of memory and summarize the content. It also includes a mechanism to provide musical therapy sessions to heal the mindset of the patient by analyzing the current emotional state. Furthermore, the system can identify the patient's loved ones and interpret their relationship with the patient. All these innovations are merged in the "DEMCARE" mobile application to provide a smart solution to improve the quality of life and the independence of Dementia patients.

Keywords—Dementia, cognitive, independence, wandering, behavior, mild, moderate

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LIST OF ABBREVIATIONS

Abbreviation	Description
LPC	Linear Predictive Coding
MFCC	Mel-frequency cestrum co-efficient
HMM	Hidden Markov Model
ASR	Automatic Speech Recognition
ANN	Artificial Neural Networks
NLP	Natural Language Processing
BART	Bidirectional and Auto-Regressive Transformers
IoT	Internet of Things
ML	Machine Learning
WSD	Wearable Sensing Devices
WHO	World Health Organization
RAM	Remote Activity/Alarm Monitoring
WBS	Work Breakdown Structure
EMEI	International Mobile Equipment Identity
RFID	Radio Frequency Identification
LSTM	Long-Short Term Memory
RNN	Recurrent Neural Network
MAE	Mean Absolute Error
MSE	Mean Squared Error
NaN	Not a Number

1. INTRODUCTION

1.1. Background & Literature Survey

Dementia patients are individuals who experience a significant decline in their cognitive and memory abilities, which can substantially impede their daily life and activities. This condition is characterized by a progressive deterioration in thinking, memory, behavior, and the capacity to carry out everyday tasks. One of the key factors contributing to the growing prevalence of dementia is the increasing number of elderly individuals in the population, coupled with rising life expectancy. These demographic shifts are largely driven by advancements in medical care and technology, which have allowed people to live longer and healthier lives. Consequently, dementia has become a pressing public health concern, and there is a growing need for effective interventions, care, and support for both patients and their families.

It is projected that every 20 years, the number of individuals living with Alzheimer's disease will nearly double [1]. As the prevalence of dementia continues to rise, so does the economic burden associated with caring for patients. In fact, the cost of providing care for a person with dementia is substantial. Currently, seven out of ten dementia patients reside at home, with their families shouldering a significant portion—about 75%—of the financial expenses associated with their care. Moreover, family members often take on the role of primary caregivers, a responsibility that can be emotionally taxing. It's worth noting that caregiving is a challenging job that can take a toll on the mental health of family caregivers, with approximately one-third of them experiencing symptoms of depression [2].

One of the additional challenges faced by family caregivers is the geographical distance that can separate them from their loved ones with dementia. Not everyone lives in close proximity, making it difficult to provide continuous monitoring and care.

Engaging in activities has been shown to enhance the quality of life for individuals with dementia. However, as the disease progresses, some activities may become increasingly challenging or impossible due to its symptoms. Therefore, it can be a formidable task for family members and caregivers to identify accessible activities and devices that can enhance the well-being and quality of life for these patients. This underscores the importance of research and support services aimed at addressing the unique needs and challenges faced by both dementia patients and their caregivers.

Improving the quality of life for individuals living with dementia is indeed a complex and multifaceted research challenge that demands a multidisciplinary approach. One of the most formidable hurdles in tackling this problem revolves around the development of a system capable of efficiently retrieving and presenting memories in a manner that resonates with the individual. Dementia often erases recent memories and familiarity with faces, which can be deeply distressing for both the person with dementia and their loved ones. Recognizing that each person with dementia possesses unique requirements and preferences, it becomes imperative to craft a memory retrieval system that is highly personalized. This tailoring of the system ensures that it aligns with the specific needs and tastes of each individual, ultimately enhancing their quality of life. A one-size-fits-all approach is not suitable in this context, as what might trigger positive emotions and engagement for one person with dementia may not have the same effect for another.

To achieve this level of personalization and effectiveness, researchers must draw upon various fields, such as cognitive psychology, neuroscience, artificial intelligence, and human-computer interaction. These multidisciplinary efforts can contribute to the development of innovative technologies and methodologies that aim to rekindle meaningful connections to past experiences, thereby providing comfort and a sense of continuity for individuals with dementia. Moreover, collaboration between researchers, healthcare professionals, caregivers, and individuals living with dementia is essential to ensure that these memory retrieval systems are both technically proficient and empathetically attuned to the unique needs of this vulnerable population.

To address these issues, we propose a solution to aid dementia individuals with better accessibility options by being able to use the application by themselves. It consists of the following four modules,

- Location tracker and predicter
- Digital audio diary
- Emotion based music player
- Face recognition system

Successfully integrating the components mentioned earlier and creating a suitable mobile-based interface with several accessibility options will enable individuals with dementia to live more comfortably day-to-day and allow them to coexist in society without feeling excluded.

Dementia affects the cells in the brain that controls memory which leads to memory impairment. People with dementia are often compelled to walk about. They don't have a place to go, or sometimes they go somewhere without knowing where they are heading to. But with memory impairment, they just feel the need to walk and move aimlessly. This is defined as "wandering" [3]. Stress, fear, overstimulation and frustration cause wandering emotionally while poor dimension perception, visual-spatial problems, poor eyesight and mobility can be physical causes. At night, boredom, perceived obligations, physical discomfort and temperature being too hot or cold can cause the same behaviour [4]. In this study, we have looked at the wandering problem and its effects on dementia patients as well as their caregivers. Research that has been done before indicates that dementia wandering is more lethal than people think in general. According to Alzheimer's Association, 60% of people with dementia are wandering during the cause of the disease [5]. There is no clear reason for this behavior thus wandering is unpredictable [6]. Caregivers and guardians of dementia patients often find themselves in stressful situations due to this behavior. They have a definite need to find a sustainable and effective solution that can take some of the burden off their shoulders. Since the beginning of the Covid-19 pandemic, monitoring patients remotely has evolved significantly and has become synonymous with the health industry with the introduction of Mobile Health. With the implementation of the sensors, identification of the patterns of movements of a patient can be done up to a certain extent so behavior out of the ordinary could be detected, identified and reported on. After conducting an analysis of existing research, apps and systems, it was found that only a few have combined these elements and have provided suitable solutions to address wandering by analyzing patients’ daily behaviors. It has received the attention that the quality of treatments for dementia patients can be improved using location-tracking mechanisms and combining them with mobile applications [2]. However, certain implementations of some research cannot be found or do not exist in the real world. This analysis enables the system to study patients' daily behavioral patterns and show patients current and predicted locations while giving the caregivers the opportunity to define safe zones (boundaries) with the capability of getting alerts when patients cross them while they are wandering using a mobile application.

The enigmatic nature of wandering poses a significant challenge for caregivers and healthcare providers alike. Understanding the multifaceted causes and emotional triggers behind this behavior is essential in developing effective strategies and interventions to enhance the safety and well-being of dementia patients. Moreover, the prevalence of wandering highlights the urgent need for innovative solutions and comprehensive support systems to address this critical aspect of dementia care.

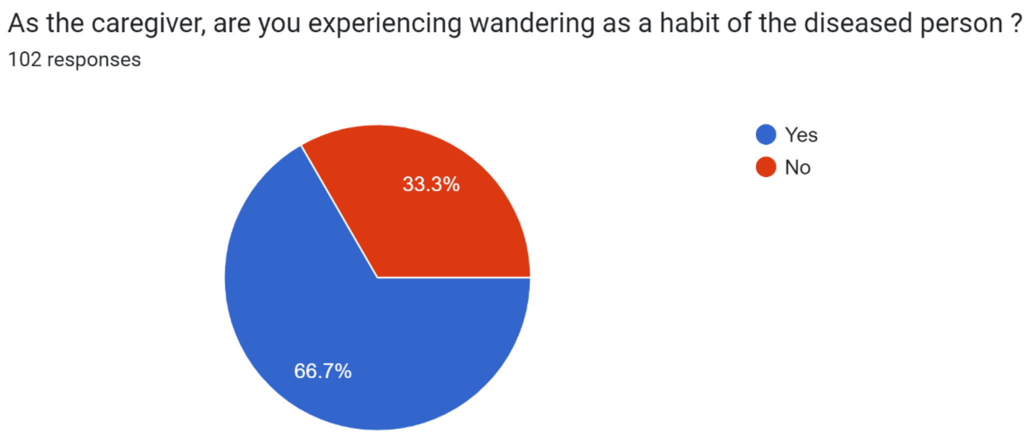


Figure 1.1. 1: Survey results on the frequency of wandering as a habit of dementia patients.

The number of people that are diseased with dementia is rising today at a larger scale. Since the beginning of 2020 due to Covid-19, people were forced to stay at their homes and elderly people who are living lonely have been affected by this to be victims of mental illnesses. Dementia has become the most common illness among them [7]. At the same time, studies show that people who were dealing with dementia morbidity and mortality from Covid-19 [8]. Although currently, people are living in post-pandemic, for elderly people it has become hard to adapt to the era of new normalization. So, in the post-pandemic, they tend to travel a lot but with short-term memory impairment, the risk of wandering is high, and this can be highly hazardous. Then caregivers need to pay more attention and put more focus towards the patients than ever before.

WSD and IoT have been identified as two of the most evolving and emerging technologies, they can be used to revolutionize the existing solutions for the wandering problem of dementia patients. Since the beginning of Covid – 19 pandemics, monitoring patients remotely has evolved significantly and it has become synonymous with the health industry with the introduction of Mobile Health [9]. With the growth of user acceptance of smartwatches for medical purposes, the general public's motive towards using technology is to reduce the complexity of their lives [10]. With the implementation of the sensors, identification of the patterns of movements of a patient can be done up to a certain extent so a behaviour out of the ordinary could be detected, identified, and reported on. It is also important to maintain bidirectional communication between the patient and the caregiver since it helps to keep the mental stability of the patients, but it is an extra burden for caregivers [11].

Figure 1.1. 2: Survey results on the stressful nature and the burden on caregivers of dementia patients

Maintaining a digital audio diary by a dementia patient has an impact on the severity of the disease condition and that helps in keeping a stable mind within the patient. Research has shown that journal-keeping could reduce dementia risk. The study, "Personal Journal Keeping and Linguistic Complexity Predict Late-Life Dementia Risk" by Jessica J. Weyerman, Cassidy Rose, and Maria C. Norton revealed that, in a larger group, having ever been a journal writer strongly predicted a 53% lower risk of dementia due to all causes [12]. This study was conducted by engaging with dementia patients and their family members via telephone calls and home visits. Some researchers mentioned a diary interview technique that has been used to investigate the daily patterns of dementia patients. In the method followed by Ruth Bartlett in the above approach, a participant records his or her thoughts and feelings under the guidance of a researcher [13]. This method was further modified to examine the lives of people with dementia. When people are asked to keep a regular journal of their experiences, rich data about individual motivations, emotions, and beliefs are collected in an unobtrusive manner over time. Researchers have used these diaries, including people with disabilities, older people and the caregivers of people with dementia for their research purposes and showed the impact of it. Using digital technologies to gather audio diaries has opened up novel opportunities for utilizing this research method with elderly individuals. This approach proves particularly advantageous when considering individuals with impairments or disabilities [13]. Nearly all of the diarists and their partners stated in "AN INDEPENDENT EVALUATION OF 'DEMENTIA DIARIES' " that the project gave them a role and a purpose. Making diary entries provided them with something worthwhile to concentrate on and strive towards. Diarists felt valuable and valued when they knew that their entries were being read and were benefiting others [14]. The project utilizes 3D-printed mobile handsets to empower individuals with dementia, known as Dementia Diarists, to record diverse experiences of living with the condition. These audio recordings are made available on the Dementia Diaries website, aiming to amplify the voices of people with dementia through media exposure.

An online survey on using diaries to assist dementia was also conducted for more data gathering and research purposes and more than 50 responses were collected.

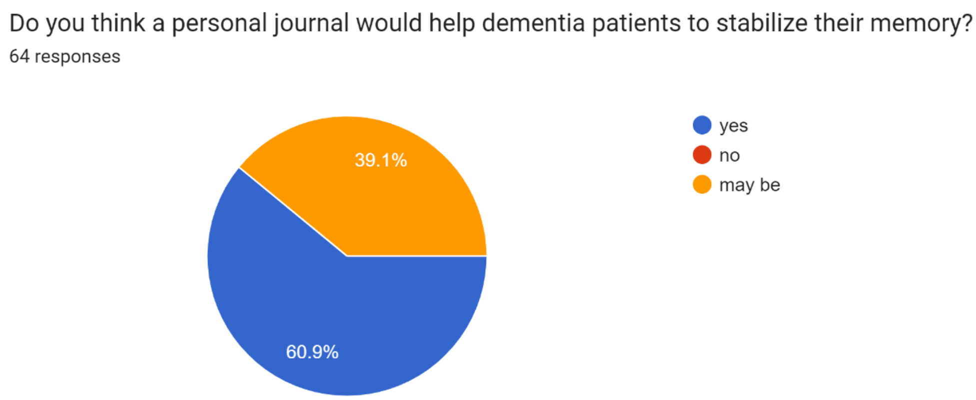


Figure 1.1. 3: Survey results on journal impact to stabilize memory.

The survey's findings suggest a link between keeping a personal journal and dementia patients' ability to stabilize their memory. When asked if keeping a personal diary helps maintain memory, the majority of respondents, 60%, said "yes," while 40% said "no." This implies that a sizable proportion of people have reported memory stabilization as a result of keeping a personal diary. Personal journals can serve as a record of everyday activities, thoughts, and feelings, which can aid memory and knowledge retention in dementia sufferers. Additionally, keeping a diary may help to lessen stress and anxiety, which can improve general cognitive function.

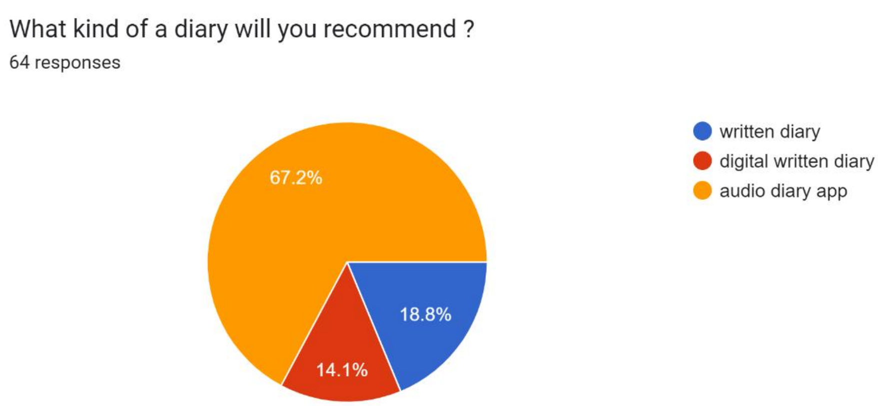


Figure 1.1. 4: Survey results on diary type

The results obtained were more favorable with the proposed system and the audience responded with positive reflections. According to the study findings, 67.2% of participants would rather keep an audio diary than a written one or a digital one. Only 18.8% of respondents said they preferred a written diary, and 14.1% said they preferred a digital diary. These results imply that many people who want to keep a private journal of their thoughts and experiences select audio diary keeping as their preferred technique.

The ease with which people can naturally and spontaneously record their thoughts and feelings makes audio diaries popular, perhaps for this reason. Audio diaries can be easily and rapidly recorded using a smartphone or other recording device, in contrast to written journals, which demand time and effort to physically transcribe material. Additionally, audio diaries might be easier for people to access who struggle with reading and writing or who might have trouble using technology. It is important to keep in mind that keeping an audio journal may have some disadvantages. For instance, organizing and searching through recordings could be more challenging than written or digital written information. Additionally, audio recordings may be prone to loss or damage, which could lead to the loss of important data.

There are several ways to extract face and audio elements from an audio signal, but very few of the systems created can generate an emotion-based music playlist based on human emotions. This component’s main goal is to improve the previous system’s weaknesses by creating an automatic emotion-based music generator that creates a personalized playlist using user-extractable facial features.

There aren’t many studies on using an emotion-based music player while targeting a dementia patient audience. According to some research work, building up music platforms was the primary objective, but the patient’s emotional state has not been taken into account while implementing the application [15] [16]. Some research is inadequate since they fail to target the dementia audience and instead focus on creating an emotion-based music player which is not user-friendly for a dementia audience [17] [18]. Any of these studies, except for research [15] do not consider the users' age when producing music which helps in producing a more personalized music playlist unique to the user.

Hafeez Kabani's research project [17] focuses on creating a music player based on human emotions. The technique captures user images via webcam or hard drive but is limited to Windows programs and has specifically mentioned the poor camera quality and lighting conditions of the application. The study uses real-time EEG to recognize emotions in music therapy using hardware like the PET 2 and Emotive wireless headset. This technology enhances human-computer interfaces, but adding additional hardware, such as sensors or EEG, may increase the design's cost.

Stuart Cunningham developed Memory Tracks, an android application for dementia patients, [15] which uses music related to daily duties. The program supports routines, care, agitation management, and memory triggering. The music is selected based on demographic information, such as birth year and childhood location, rather than considering the patient's emotional state. Alive Inside [16] is a customized music-streaming app for dementia patients, offering personalized listening lists based on users' unique lives. However, as mentioned previously the app's biggest flaw is not considering patients' emotional condition when creating their profiles.

Various tools have been built to aid dementia patients in several ways. However, majority of them are built up for the use of the caregiver and they are missing some critical factors that should be improved to be used by the patient themself. According to the referred information, an assistant is mandatory for these individuals to interact with the rest of the world on a daily basis and to improve their quality of life. As shown in Figure 1.1-3 which denotes the data retrieved by the survey implemented, it is validated that most of the people stated that a digital assistant is mandatory for these individuals. According to the referred information, a digital assistant is mandatory for cognitive disabled individuals to improve their quality of life and independence with the help of music (Figure 1.1-3). This assistant will guide these people to necessary music sessions in accordance with those emotions.

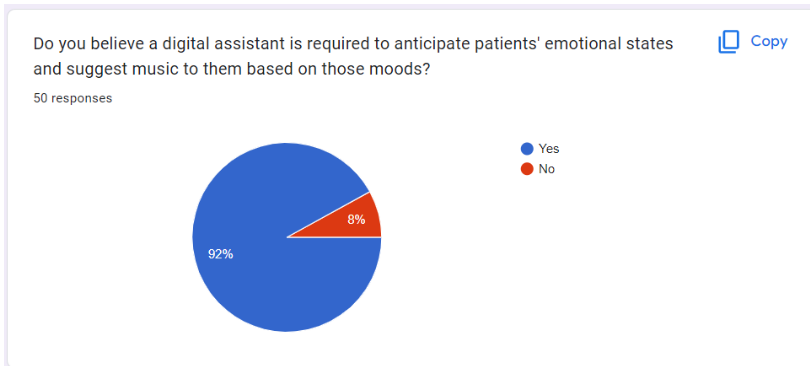


Figure 1.1. 5: Survey responses on the importance of a digital assistant

However, as already mentioned, the main method by which these dementia patients are directed towards musical therapy sessions is with the assistance of a third party. Given their current emotional condition, these people cannot be made open to more precise or successful therapy sessions, Figure 1.1-4 depicts it too. Some people have remarked that it is not always effective to direct dementia patients to necessary music therapy sessions when a third party is involved. They have stated that the current mood these individuals are in is particularly important when it comes to these sessions, and these caregivers/family members will not always be able to discern it accurately and these people to help with cannot be around all the time. So, it emphasizes that, a smart assistant is very important for a dementia individual when it comes to conducting music therapy sessions.

According to the data gathered by the survey, the pie chart in Figure 1.1-5 shows that the majority of respondents believe using an assistive tool makes it easier for a person with dementia to be directed to the right music therapy sessions according to their emotions to improve their quality of life and independence, while the least amount of respondents' support receiving assistance from a third party.

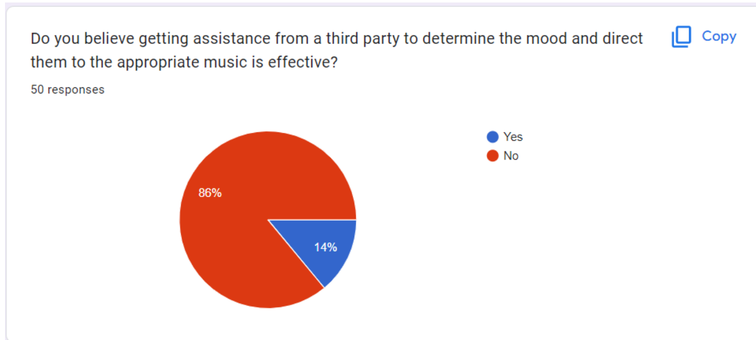


Figure 1.1. 6: Survey results on the effectiveness of a third party

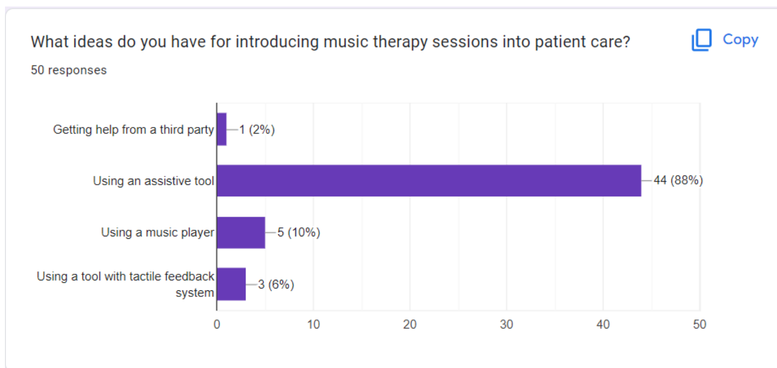


Figure 1.1. 7: Survey results on the suggestions for dementia individuals to introduce music

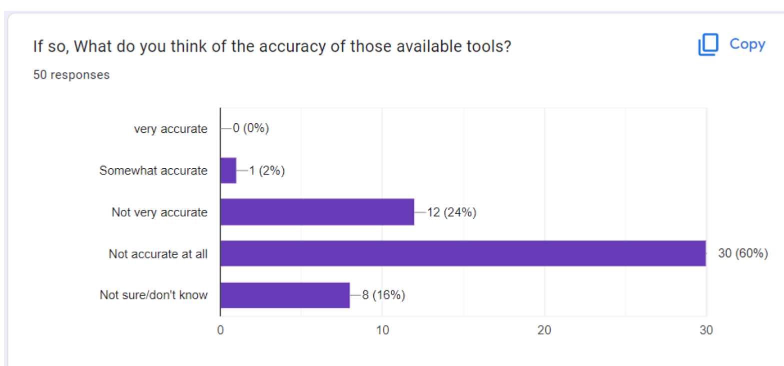


Figure 1.1. 8: Survey results on accuracy of the available tools

Moreover, technical improvements have made it possible to recognize emotions and predict music in accordance with those using a variety of software and apps. As seen in Figure 1.1-6 mandatory responses are for low accuracy for existing digital assistants. Many claims that the devices currently available do not accurately detect emotions and are not user-friendly for dementia patients. The literature reviews in article [17] vividly illustrate the operation of similar systems that are already in place, as well as their benefits and drawbacks.

Short-term memory impairment stands out as a prominent challenge faced by individuals with dementia, hindering their ability to recognize and identify their family members, friends, and other loved ones, which directly affects their independence, making it challenging for them to recognize familiar faces, including their own and those of their friends and relatives [19] [20]. This inability to connect with familiar faces often leads to feelings of frustration, anxiety, and emotional distress, not only for individuals with dementia but also for their family members. Consequently, the mental well-being and quality of life of both parties are significantly affected.

When studying the literature points, various tools have been built to recognize faces, and several assistive tools have also been implemented for normal people. Most of the existing solutions are implemented for a limited audience and lack functions. Non-pharmacological management of dementia puts a burden on those who are taking care of a patient [21].

To address this issue, the development of a face recognition mechanism for detecting and identifying familiar faces of dementia patients has emerged as a potential solution.
Most existing facial recognition software is designed for use by caretakers, giving them aid in keeping a close eye on their dementia patients. The uniqueness of our solution and others is that it was developed with the input of people living with dementia, considering their preferences, skills, and limitations.

By creating a real-time face recognition system, researchers aim to enhance the quality of life and independence of individuals with dementia. Despite the growing body of literature on dementia care, studies focusing specifically on real-time face recognition mechanisms for detecting familiar faces among dementia patients remain scarce. Thus, there is a need for further research in this area to explore the effectiveness and feasibility of such mechanisms in improving the lives of individuals with dementia.

Furthermore, our solution goes beyond just face recognition and adds value by incorporating additional features that are beneficial to dementia patients. For example, instead of providing a brief introduction of the person (name and the relationship between the patient), it may include prompts for memory slides regarding the captured person after detecting the person's face. These features are specifically tailored to address the needs of dementia patients, make them more interactive, and promote their well-being, and independence.

With the purpose of creating an assistive tool for identifying familiar faces, we conducted a survey of random 50 people in the society. According to the survey that we conduct, the majority of people respond about the emotional impact. (Figure 1.0). This is one of the major problems that have for dementia patients and their loved ones.

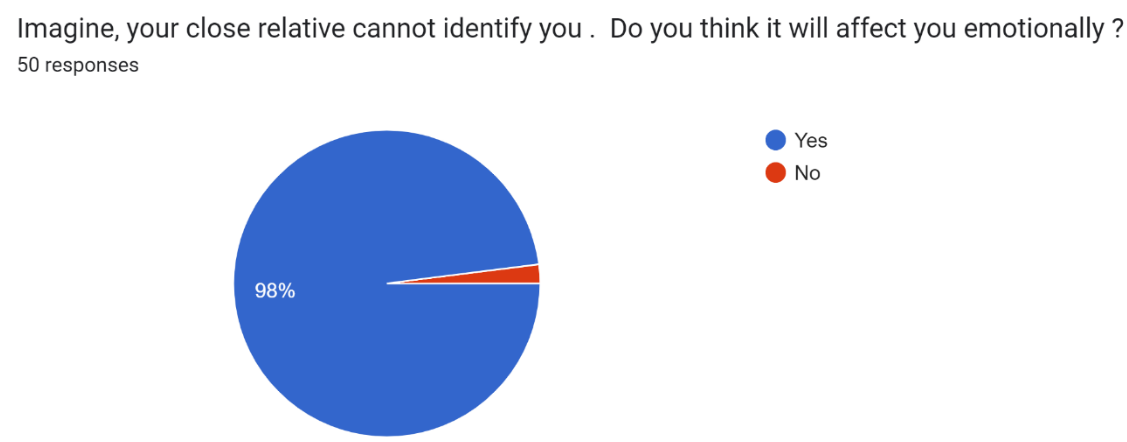


Figure 1.1. 9: Survey results that about the emotional impact

In addition to that, the family also takes on the role of primary caregiver, which is frequently an emotionally challenging and very stressful job. One-third of individuals with depressive symptoms were family caretakers. Initially, it can be quite difficult for the distant caregiver to continuously monitor patients as not everyone is living closer by [21]. According to medical data, in Asian countries, most dementia patients live alone, without any caregivers. Therefore, they cannot always get a help from third parties to maintain their day-to-day lives. As the people who know the value of independence, we want to improve their quality of life and make them more independent.

As shown in figure 1.1 our survey shows that most participants considered the importance of identifying their loved ones and familiar faces to maintain an independent life.

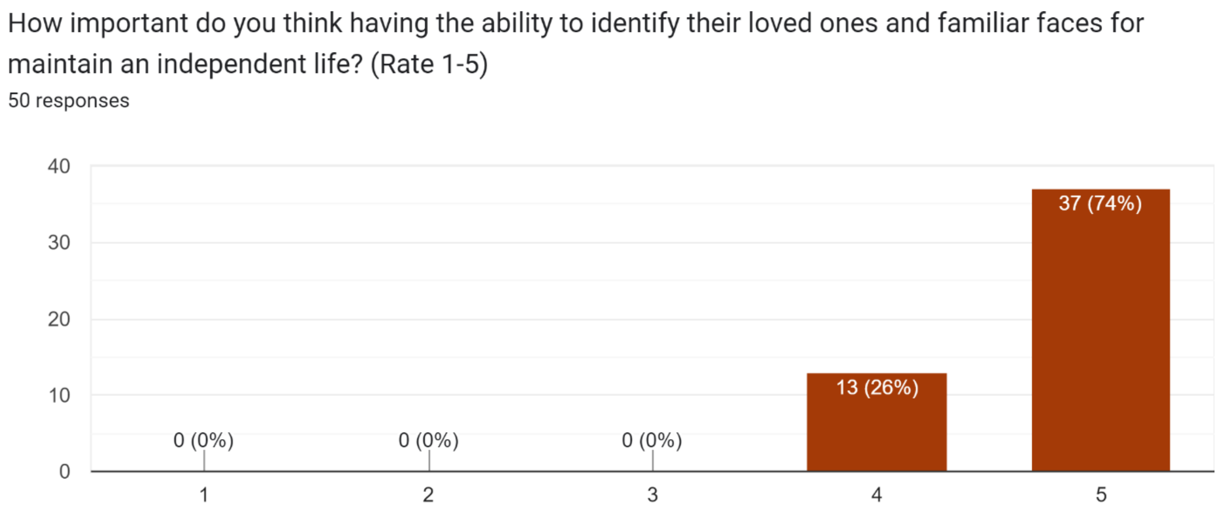


Figure 1.1. 10: The importance of the ability to identify faces.

Even though there are traditional solutions like having a caregiver to aid these kinds of individuals to recall their memory, since not all caregivers live in close proximity, remote monitoring may be a challenge [21]. As shown in figure 1.2 our survey shows that most people in society think all dementia patients haven't the ability to keep a caregiver for their day to lives.

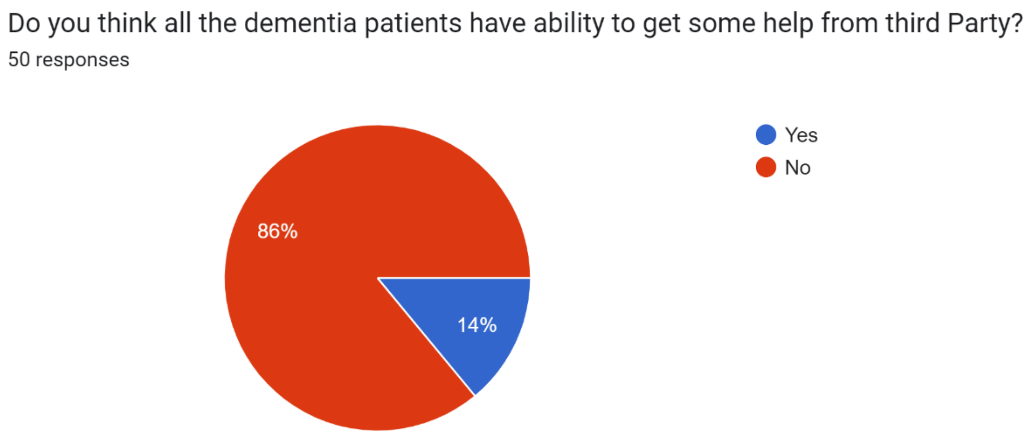


Figure 1.1. 11: Survey results that regarding the help of third party

According to the Sri Lankan hospital data, most mild and moderate-level dementia patients spend their time alone. And the other main considerable thing is the cost of caring for a patient with dementia is high. Seven out of ten people with this condition live at home, where their families pay for the majority (75%) of their maintenance. As a solution to this issue, we ask what the effective and easy ways are to avoid those difficulties. Then we received some answers as shown in figure 1.3. The majority of society agree with making an assistive tool for dementia patients to identify their familiar faces is the most efficient and effective way to improve their quality of life.

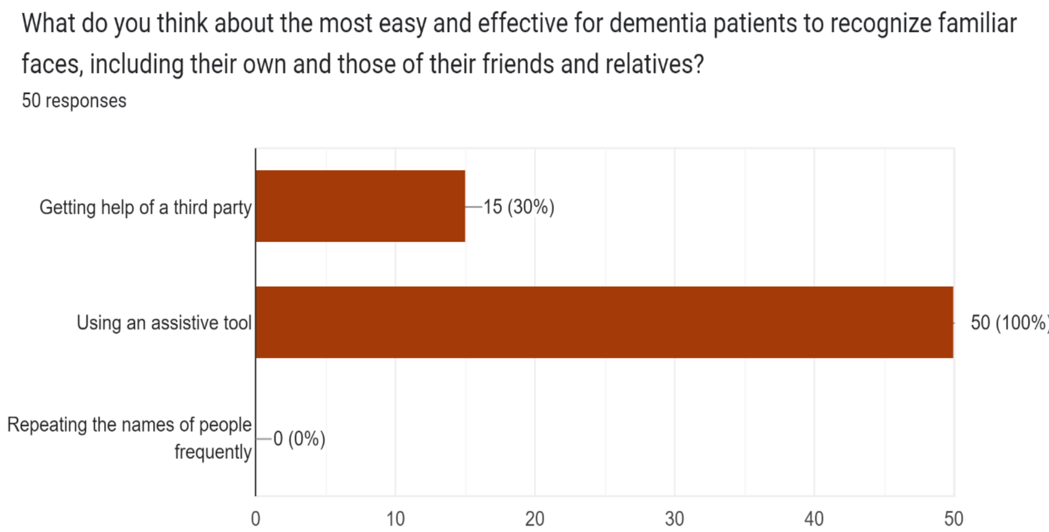


Figure 1.1. 12: Survey results that display the effective and easy way to recognize familiar faces of dementia patients.

1.2. Research Gap

When considering the whole system, there are already implemented mobile tools to assist dementia patients. But most of them are implemented considering a particular cognitive impairment. Demcare is developed considering all the possible cognitive conditions of a dementia patient. The findings promote the independence of dementia patients and collaborate them to improve their quality of life.

1.2.1. Gap – location tracker

When considering the whole system, there is a very limited number of devices and tools which have been implemented to assist Dementia patients, but the wandering problem has not been addressed by most of them. Also, they lack certain key functionalities and some of them are highly outdated. Because of this, caregivers search for new technical solutions which are current and futuristic. Most existing options have not been built to establish safe zones facility for caregivers which can massively impact the well-being of the patient and minimize the burden on caregivers' shoulders.

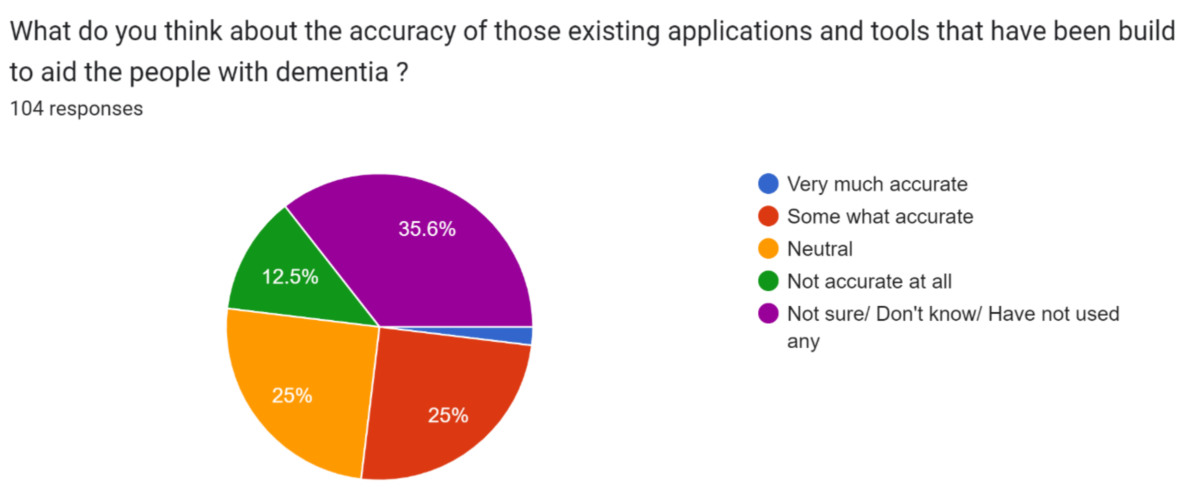


Figure 1.2.1. 1: Survey results on user experience and satisfaction with existing applications and tools

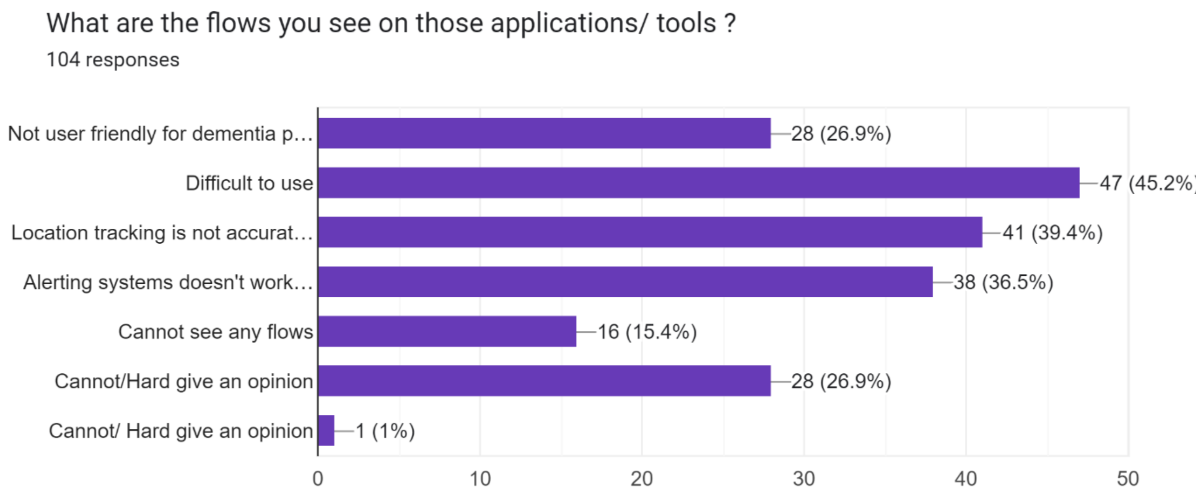


Figure 1.2.1. 2: Users' ideology about existing tools and their flows/ what areas mainly need to address.

Although there are some researches has been done regarding the wandering problem of dementia patients, certain implementations cannot be found in the real world [2]. Research A [22] paper explains assistive mobile health applications and wearable IoT devices have been developed for patients who are in the early stages of Alzheimer's disease (which is a diagnosis of dementia) to maintain their mental activeness. Research B [2] paper explores the movement and location tracking mechanism that has been built for dementia patients. Research C [23] (Real-time Location Tracker for Critical Health Patient using Arduino, GPS Neo6m and GSM Sim800L in Health Care) paper describes the real-time location tracking system which has been built using sensors, google maps and tools such as Arduino boards.

Table 1.2. 1: Research gap by comparing the proposed system with existing systems.

	Research A [22]	Research B [2]	Research C [23]	Proposed system
Track the current location of the patient and monitor movement and speed constantly	×	✓	✓	✓
Establish safe zones and change them according to the whereabouts at the time by caregivers	×	×	×	✓
Analyze patient's historical records and predict future movements	×	×	×	✓
Alarming & alerting system for emergencies	×	✓	×	✓

As of now, there exists no research or application that harnesses the wealth of data within a patient's historical records of frequently visited places to analyze and predict their future movements, thereby mitigating and preventing potential disasters. Considering this research gap, we propose the development of an innovative mobile application that seamlessly integrates with a location tracking device. This application is envisioned to offer a comprehensive solution, addressing the critical need for predictive capabilities in dementia care.

The core concept underlying this groundbreaking application is the utilization of a patient's historical location data. By collecting and analyzing data on places the patient has visited frequently, we can uncover valuable insights into their behavioral patterns and preferences. This, in turn, forms the foundation for predicting the patient's future movements with a high degree of accuracy.

The key functionalities of this proposed mobile application include real-time location tracking and analysis, intelligent predictive algorithms, and customizable safe zones. Patients would wear a location tracking device that communicates with the mobile app, continually updating the patient's whereabouts. The app would then employ advanced algorithms to identify patterns and trends in the patient's movements, using the historical data as a reference.

The predictive capabilities of this application hold immense promise. Caregivers and healthcare professionals would be alerted when a patient deviates from their expected routine or enters potentially hazardous areas. This proactive approach has the potential to prevent accidents, injuries, and even fatalities.

Moreover, the application aims to provide patients with a degree of independence while ensuring their safety. Carefully defined safe zones can be configured, allowing patients to move within these boundaries without triggering alarms. This balance between independence and safety fosters a sense of autonomy for dementia patients.

In summary, the proposed mobile application represents a significant leap forward in dementia care. By harnessing the untapped potential of historical location data, it offers the means to predict patient movements, minimize risks, and enhance the quality of life for both patients and caregivers. This innovative solution has the potential to bridge the existing research gap and make a profound impact on dementia care, ensuring a safer and more dignified life for those affected by this condition.

1.2.2. Gap – audio diary

According to the literature survey, most of the diaries are maintained to collect data and caregivers were responsible in a way during the process. But the outcome of this system is to improve the independence of the dementia patient. Therefore, patient-friendly techniques are used in the proposed system. The main benefit is that this is an audio diary. It helps elderly patients. They can access the diary even without any help from the others. An audio diary is easier to handle than a written diary because the literacy levels are much lower among the dementia patients.

However, there are enough evidence to say that this diary keeping technique is beneficial to a dementia patient. Some related work say that patients even enjoyed diary wring as well [13]. When their life patterns are recorded on a daily basis, they get familiarized with the daily routine and this leads in improvement in their memory. Therefore, the condition of the illness can be reduced or kept without being severely affected.

When comparing the data collected and proposed deliverables, there is no existing system or a single application that includes all the functionalities given in the following table.

Table 1.2. 2: Research gap

	[12]	[13]	[14]	Proposed system
Including audio recordings of patients	no	yes	yes	yes
Usage of voice recognition	no	yes	yes	yes
Speech to text conversion and storage of text files	no	no	no	yes
Calendar based diary to access daily diary records	no	no	no	yes
Text summarization	no	no	no	yes

This research component of the proposed system includes all of the above-mentioned features. Since there are no any application with all the features the proposed system to be implemented is a novel innovative creation.

1.2.3. Gap – music player

As previously noted in the literature survey, numerous methods have been used to anticipate music in accordance with emotional state, however they have significant limitations, such as

I. For extracting facial features in real time, current methods are quite sophisticated in terms of time and memory needs.

II. Existing methods are less accurate at creating playlists based on a user's current emotional state and behavior.

III. Several current systems need additional hardware to generate an automated playlist, which raises the overall cost.

IV. Several systems now in use produce unpredictable results when subjected to lighting and camera conditions that are both quite poor.

V. These systems do not focus on keeping the patient engaged throughout these sessions.

Table 1.2. 3: Research gap compared to existing systems

	Research A [17]	Research B [15]	Research C [16]	Research D [18]	Research E [24]	Our Solution
Assist Emotion Feature Extraction	Yes	No	No	Yes	Yes	Yes
optimized for mobile/ cloud use	No	Yes	Yes	No	No	Yes
Detect Age and classify music separately	No	Yes	Yes	No	No	Yes
Visual Presentations accordance with the classified Music	No	No	No	No	No	Yes
Build A music Library based on real time patient Reaction	No	No	No	No	No	Yes

Table 1.2-1 also makes a brief comparison between the suggested solution and the identified problems with the current systems. Reviewing the results reveals that this solution is implemented with far more innovative functionalities than other studies that are currently being done.

1.2.4. Gap – face recognition

Comparing recent research on facial recognition applications and dementia patients there is a very lack of research exploring the effective and efficient system for directly targeting the dementia patients. When studying literature points, various tools have been built to recognize faces, and several assistive tools have also been implemented for normal people.

Most of the existing solutions are implemented for a limited audience and lack functions. Providing non-pharmacological care for dementia patients places a significant responsibility on the caregivers [21].
Most existing facial recognition software is designed for use by caretakers, giving them aid in keeping a close eye on their dementia patients. The uniqueness of our solution and others is that it was developed with the input of people living with dementia, considering their preferences, skills, and limitations.

Knowing that people with dementia have cognitive impairments, we designed facial recognition software specifically for them. The interface and functionality have been developed with individuals with dementia in mind, making them easy to use and accessible. The application sets a priority on the user's capacity to identify familiar faces, which in turn provides the individual with a feeling of comfort, safety, autonomy, and independence.

In below mentioned table display the summary of the comparison of the existing solutions and our solution. By reviewing the table below, you can come up with an idea that what are the novelties of the implemented solution.

Table 1.2. 4: Research gap for document segmentation and classification with existing system

Features	**Research A** [25]	**Research B** [20]	**Research C** [19]	**Solution**
A real-time image-capturing option using the smartphone camera	X	√	X	√
Screening the person’s Information	√	√	X	√
Use a text-to-speech module to hear the information	X	√	X	√
Special user interface creation for dementia patients	X	X	√	√
Use object recognition mechanism to filter a memory, related to the captured person	X	X	X	√

1.3. Research Problem

The main significant feature of a dementia patient is the occurrence of memory impairments. Forgetting things can increase the complexity of their lives. They even have to face many challenges when living. Sometimes this can be a difficulty to their family and caretakers as well. As we focus on the patient's independence, the proposed solutions are directed towards that. We are considering the mild to moderate stages of the disease and most of the affected persons are older.

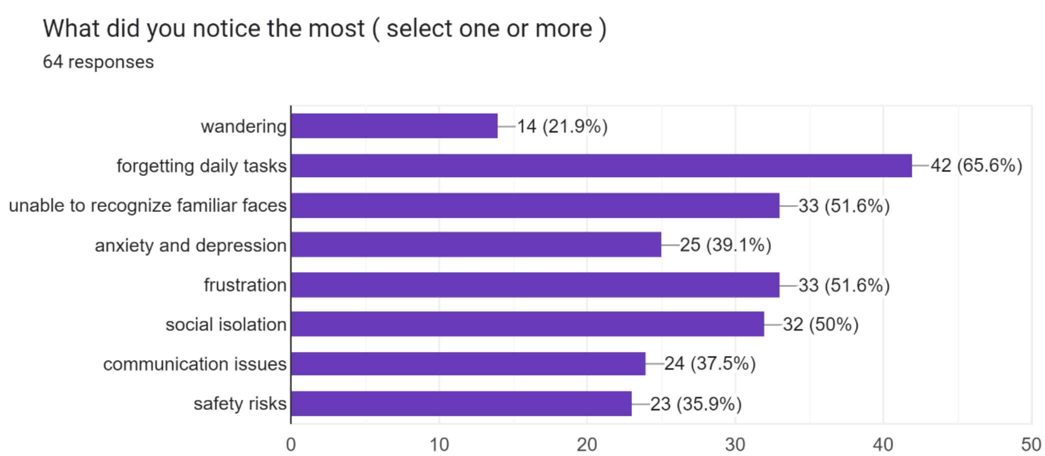


Figure 1.3. 1: Survey results on noticing behavior.

The above figure shows the responses for noticing the behavioral patterns of dementia patients by the audience.

Dementia patients may forget how to perform routine activities such as dressing, grooming, and cooking, which can make them reliant on others for assistance. They can keep a note regarding such details as well. Because later this can help them remember things. Dementia patients may struggle to remember people's names and faces, which can make social interactions difficult and lead to social isolation. This isolation also can be eradicated if they keep tracking these requirements. They may forget words or struggle to form coherent sentences, making communication difficult. By keeping a diary their literacy skills and then communication skills can also be improved. Forgetting things can be frustrating and stressful for dementia patients, leading to agitation and behavioral issues. Such instances can also be avoided if they practice keeping a personal journal with them. Overall, forgetting things can have a significant impact on the daily life and well-being of dementia patients, and strategies to manage this symptom are an important part of their care plan.

Finding techniques to enhance memory function can significantly benefit someone with dementia's quality of life because memory retention is one of their main concerns. It is possible to increase people's capacity for communication and social interaction by giving them the tools and techniques necessary to remember information and recall significant experiences. Another crucial factor in raising the quality of life for those with dementia is improving communication abilities. Communication difficulties that arise as the illness worsens might make people feel frustrated and alone. It is possible to enhance a person's capacity to connect with people and uphold social ties by giving them the tools necessary to speak more successfully, such as speech therapy or assistive technologies. Dementia sufferers must also take their emotional health into account. Anxiety, depression, and other emotional difficulties may accompany the illness and negatively affect the patient's general quality of life. It is possible to assist people in coping with these difficulties and preserving their sense of well-being by offering emotional support, such as therapy or support groups.

2. RESEARCH OBJECTIVES

2.1. Main Objective

Designing a smart solution via an application to improve the quality of life and the independence of a Dementia patient is the main objective of the proposed whole system. Improving the independence and quality of life of dementia patients requires a holistic approach that addresses physical, emotional, and environmental factors. Working with healthcare professionals and caregivers can help develop an individualized plan that meets the unique needs of each patient. The proposed system basically covers most of the above-mentioned factors.

2.2. Specific Objectives

With the above-mentioned main objective, the following specific objectives are intended to be accomplished when it comes to the whole component and overall implementations.

To track patients' locations in real-time.

- The fundamental goal of managing the problem of wandering among dementia patients is to maintain constant awareness of the persons who are prone to wandering and the sites they frequent. This necessitates the incorporation of a dependable real-time location tracking system. While similar systems do exist in the real world, carers have expressed reservations about their accuracy and effectiveness. These concerns emerge from the important necessity for precision in assuring dementia patients' safety.
- Caregivers are entrusted with the difficult task of keeping constant tabs on dementia patients, particularly those who wander. The limits of conventional location monitoring methods, on the other hand, have encouraged the search for a more dependable and user-friendly alternative.

- The proposed location tracking device offers a robust solution by capturing and transmitting the real-time location of the patient. Caregivers can access this information conveniently through their mobile devices, allowing them to monitor the patient's movements with greater accuracy and peace of mind. This real-time tracking capability represents a significant advancement in the realm of dementia care, offering caregivers a valuable tool to enhance patient safety while alleviating some of the burdens associated with constant supervision.

To identify the established safe zones with customizable options while giving alerts to caregivers in emergencies

- It is required to have a suitable and matching method to establish boundaries in the virtual map while analyzing the real geographical locations. For this geofencing will be used since it has the most efficiency and reliability. Alerts will be triggered when patients cross those defined virtual boundaries. The option to customize those boundaries according to the place will be provided to the caregivers.

To build a predictive model to analyze patients' historic records and predict future movements.

- After gathering location-related data via the tracking device, the same can be used to predict future movements using ML techniques. Decision Tree and Random Forest algorithms will be used to generate predictions with high accuracy.

Improving the cognitive independence and wellbeing of dementia patients by motivating them to maintain a digital audio diary.

User's voice detection and speech recognition

- a proper mechanism should be implemented to detect the user’s voice via the mobile phone. Implementing a robust mechanism for detecting the user's voice through their mobile phone is paramount to the success of this application. The ability to seamlessly capture and recognize the user's voice enables a natural and intuitive interaction with the system. By ensuring precise voice detection and speech recognition, the application not only enhances accessibility but also empowers users, particularly those with mobility or cognitive impairments. This feature fosters inclusivity and ensures that the technology can be effectively utilized by a diverse range of individuals, ultimately improving the overall user experience.

Converting speech to text

- user’s speech should be converted into text in order to save them as text files to view them in future. The conversion of user speech into text is a fundamental function that underpins the practicality and utility of the application. By transforming spoken words into written text, this technology provides users with a tangible record of their thoughts and experiences. These text files serve as valuable digital diaries, preserving personal memories and insights for future reference. This feature has far-reaching implications, particularly in healthcare and personal documentation, as it simplifies the process of recording and reviewing information. Moreover, it aligns with the broader trend of digitizing and organizing information in an increasingly digital world.

Text summarization

- It is possible to create a summary of the text that highlights the most significant information, providing a more concise version of the original text. The capability to create concise summaries of the transcribed text marks a significant advancement in information management and accessibility. Text summarization technology distills lengthy narratives into succinct, coherent, and informative summaries, accentuating the most salient details. This function not only saves users valuable time but also enhances comprehension by providing a snapshot of the essential information. In various contexts, such as educational content, news articles, or personal diaries, text summarization streamlines the consumption of information, making it more digestible and accessible. The ability to offer users a concise version of the original text significantly contributes to the efficiency and effectiveness of the application, ensuring its relevance in today's fast-paced world.

Improving cognitive independence of dementia patients by directing them to the appropriate music therapy sessions while analyzing their emotions.

Date set preparation

- The emotional detection algorithm in this project was trained using an existing dataset. The dataset was already labeled with emotional categories after being carefully selected for its relevance and quality, which reduced the requirement for complicated data collection and annotation. For the purpose of ensuring compatibility with the selected machine learning model, data preprocessing, including cleaning and formatting, was carried out. The succeeding stages of model development were accelerated by this streamlined method of dataset preparation.

Model training

- This phase's main focus was on hyperparameter tuning, training, and model selection. Hyperparameter optimization methods were used to fine-tune an appropriate machine learning model that was selected based on the characteristics of the dataset. For the model to function at its best on the preprocessed dataset, several training iterations were completed. The foundation for the emotional detection system's next stages was formed by this effective model training procedure, which also showed how easily it could be modified to work with current datasets.

Choosing the appropriate therapeutic music session using an emotion-audio integration module

- Provide a music therapy session recommendation module that can reliably identify a patient's emotional condition. Here, have to create a database of music therapy sessions that have been proven to be successful in treating particular emotional states in dementia patients by doing research and collecting the data. Based on client feedback and new research findings, continuously update and improve the emotion-audio integration module and music therapy session database. To avoid overstimulating or disturbing the patient, have to make sure the music therapy sessions you choose are appropriate for their cognitive and physical skills.

Improving the cognitive independence and wellbeing of dementia patients by providing them with a face recognition system to identify their loved ones.

Developing the proper algorithm for detecting familiar faces and providing the user with information about the person.

Creating a recollection of that individual or a slideshow of photos with that person for the patient to watch. Additionally, developing access to an album where he can see memory slideshows whenever he wants.

Face detection: This involves locating faces in an image or video.

Feature extraction:

- This involves extracting facial features, such as the eyes, nose, mouth, and shape of the face, to create a unique facial representation or feature vector.

Face comparison:

- This involves comparing two or more facial representations to determine if they belong to the same person or not. Face verification:
- This involves confirming the identity of an individual by comparing their facial features to those stored in the AWS S3 bucket.

Face recognition:

- This involves identifying an individual by matching their facial features to a bucket of known individuals.

Implement a text-speech library to get the voice output of the displayed content.

3. METHODOLOGY

3.1. Methodology

3.1.1. Location tracker

The primary goal of this research is to build and execute a comprehensive system aimed at improving dementia patients' cognitive independence through the integration of a machine learning-enabled mobile application. The specific role and contribution within the scope of this vast project focuses around in-depth research, exhaustive study, and meticulous analysis of the wandering behavior shown by dementia patients.

Understanding the complexities of dementia wandering is critical to the success of this program. A more detailed understanding can be acquired by looking into the behavioral patterns and underlying reasons of wandering. This extensive research serves as the foundation for developing an efficient and timely answer.

The ultimate objective is to provide caregivers and healthcare professionals with an innovative and efficient solution that mitigates the challenges posed by wandering behavior in dementia patients. This solution, rooted in the insights and findings derived from this dedicated research, seeks to empower patients and enhance their cognitive independence, thereby contributing to a higher quality of life for those affected by dementia.

The utilization of a tracking device for real-time location monitoring via a mobile phone represents a groundbreaking development that effectively alleviates a significant portion of the stress and burden borne by caregivers responsible for dementia patients. The constant need for vigilant supervision can be overwhelming, but this innovative solution offers a much-needed respite. Caregivers no longer have to maintain unwavering focus on their patients at all times, thanks to the real-time tracking capabilities afforded by the mobile device.

Furthermore, the capacity to create and modify safe zones based on the patient's current environment emerges as a significant benefit for both caregivers and patients. These safe zones are preset boundaries within which patients can move without generating alerts. Caregivers may customize these zones to their preferences and the individual needs of the patient, encouraging a sense of control and personalization in dementia care.

The device and mobile application are linked by a sim card and the EMEI number that comes with the device. EMEI numbers function similarly to bar codes and vary from device to device. Location and movement tracking rely on modern sensors that are easily incorporated into the system. These sensors not only provide accurate real-time location data, but also provide information on the patient's movements. This multidimensional strategy improves carers' abilities to safeguard the safety and well-being of patients.

The entire system is designed to be accessible through user-friendly mobile applications, placing the power to define safe zones directly in the hands of caregivers. This convenience empowers caregivers to tailor the solution to the unique requirements of each patient and living environment, further reducing stress and enhancing the effectiveness of dementia care.

In essence, the inclusion of sensors and mobile applications into this system represents a watershed moment in dementia care. It not only relieves caregivers of the constant need for undivided attention, but it also offers them tools to make caregiving safer and more personalized. Finally, this comprehensive approach to dementia care strives to improve the quality of life for both patients and carers.

The tracking device was included as a result of a strategic relationship formed with Keygan Security Pvt Ltd. The VT03D is an innovative device that serves as a portable tracking solution, utilizing the power of a SIM card for activation and seamless interaction with the dedicated mobile application. This portable device is meant to track vehicles, but we have managed to convert that to track locations of humans. The device's commitment to protecting the privacy and security of each individual unit is a critical part of its design. This is accomplished by assigning unique EMEI numbers, which ensures differentiation and increases security.

VT03D incorporates a range of essential components, including microcontrollers, sensors, actuators, enclosures, displays, and batteries. In location tracking mechanisms, each of these features are playing a pivotal role in its robust functionality [26] . Microcontrollers serve as the backbone of the device, contributing significantly to its efficiency and overall functionality. Their presence ensures that this device as an efficient, well-functioning, and highly realistic location monitoring solution [26]. To capture actual real-time data, the device is equipped with sensors, a fundamental element that has proven to be highly effective in the realm of location tracking systems [27]. The inclusion of enclosures in the device design serves a dual purpose. Not only do they enhance the overall security of VT03D by providing physical protection for its internal components, but they also contribute to a reduction in development costs. Actuators are employed to facilitate the device's alerting and alarming functionality, ensuring that timely notifications can be issued in response to potential risks or emergencies. Given the device's intended use, batteries serve as the primary power source. This choice is driven by the necessity for VT03D to remain with patients for extended periods, necessitating a reliable and portable energy solution.

The inclusion of the Google Maps API, a powerful tool famous for its ability to offer real-time parameters and measures with outstanding precision [28], makes tracking patients' positions a breeze. Using this API's features ensures that the location monitoring system runs at the highest levels of precision and dependability.

To establish safe zones for patients, the system incorporates geofencing technology, a sophisticated approach that effectively creates virtual barriers corresponding to real-world geographical locations [29]. This feature allows caregivers to define specific areas within which patients can safely move. RFID is used to determine real world locations and trigger messages to the backend.

A key advantage of this system is the continuous and real-time monitoring of patients' locations and movements, affording caregivers the flexibility to stay informed whenever they choose. This level of access and insight into patient activity empowers caregivers to provide timely assistance and intervention when needed.

The device improves patient safety even more by triggering actions when patients leave or enter predetermined bounds. In reaction to these events, the system may automatically send warnings to authorized carers, ensuring that any deviations from the safe zones are communicated to them as soon as possible.

Importantly, even when patients venture outside the safe zones, their location continues to be actively monitored. Should they return to the safe zone before any adverse events occur, the system promptly notifies the caregivers overseeing the patients. This dynamic and proactive approach not only enhances patient safety but also provides caregivers with valuable reassurance, knowing that they will be alerted to any potential risks or incidents. All the historical data regarding the places that the patients mostly visited or frequently visit, how many times he or she has crossed the defined safe zones, and patterns of movement will be stored within the system and after 4 months period, a new feature will be available for caregivers where the system is predicting the movement of the patients by analyzing and training those gathered data. A decision tree algorithm is a collection of simple decision rules that enable decision makers to make timely and suitable decisions about location prediction [30]. In the latest research, it has been found that random forest algorithms are more efficient and timely methods for location related predictions [31].

3.1.2. Audio diary

This research component is divided into two main aspects where one part covers the voice recognition and voice to text conversion while the other part includes text summarization mechanism. For the voice recognition and voice to text conversion react native voice library is used. The text summarization is implemented with fine tuning the hugging face BART model [32].

Voice recognition can be achieved by integrating the react-native-voice library. After setting up the project and installing the library, need to request permissions to access the device's microphone. Then, in the user interface where users can trigger voice recognition, a button can be implemented. Within the component, we can use the library's methods to start the recognition process, specifying the desired locale. Callback functions like onSpeechResults will provide the recognized speech, allowing to handle the results as needed. It's essential to implement error handling, stop recognition when it's no longer needed, and thoroughly test the feature on various devices [33].

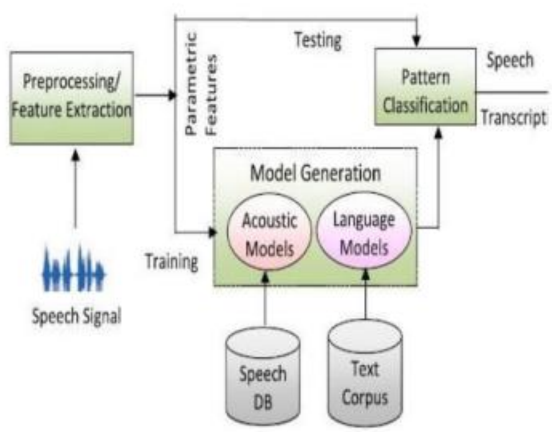


Figure 3.1.1. 1: Structure of a basic voice recognition model

When converting voice to text, a separate button can be triggered, by taking voice recordings as input. React-native-voice library can process the recorded audio and convert it into text. The recognized text can then be displayed or saved as needed.

Hugging Face's BART (Bidirectional and Auto-Regressive Transformers) model stands out as a formidable tool for text summarization tasks. Its unique prowess lies in its ability to effortlessly distill lengthy texts into concise and coherent summaries, making it a sought-after resource for a wide array of natural language processing applications. BART achieves this through a sophisticated fusion of bidirectional and autoregressive transformers. By comprehensively understanding the context and intricate relationships within a given text, BART captures the essence of the source material with remarkable precision. This capacity for nuanced comprehension allows BART to reconstruct the content in a more compact and digestible form, resulting in summaries that are both informative and succinct. Whether it's condensing extensive documents, distilling the core insights from news articles, or simplifying complex information for improved accessibility, BART's summarization capabilities have proven invaluable across diverse domains. Moreover, the flexibility to fine-tune BART on specific datasets or domains empowers developers and researchers to create highly effective, domain-specific summarization models, further enhancing its utility in extracting key insights and aiding decision-making processes [34].

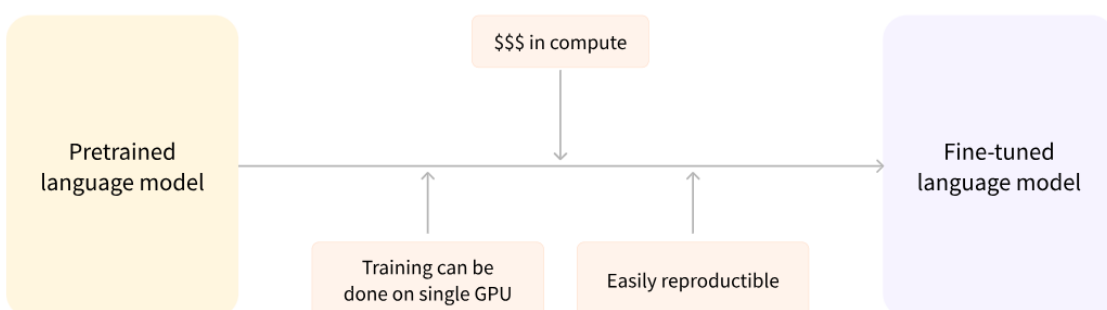


Figure 3.1.1. 2: Finetuning BART model

This approach can be used to summarize the text content in the diary and make it available for the caregivers to take a review about the diary records.

3.1.3. Music player

In this research project, we apply a comprehensive approach to improve user experience by making recommendations for music that are driven by emotions. We start by choosing the FER-2013 dataset, a vast collection of facial expressions representing a range of seven emotional states. The training set, the public test set, and the private test set are three subsets that were carefully divided up into this dataset. Our CNN model is trained using the training set, which consists of 28,709 pictures.

We gradually create a CNN model for face expression identification using this dataset. Multiple convolutional layers followed by max-pooling layers make up the CNN design, which enables the model to recognize complex spatial patterns and feature hierarchies in facial pictures. To improve model convergence and feature learning, batch normalization and ReLU activation functions are included in each convolutional layer. Three separate blocks that each gradually decrease spatial dimensions while raising the amount of abstraction make up the CNN's structure. A flatten layer follows these convolutional layers and gets the data ready for fully linked (dense) layers. Further non-linearity and abstraction are introduced by the dense layers. Softmax activation-equipped output layer makes predictions about each image's emotions.

The development of a user-friendly React Native mobile application allows users to quickly and easily capture their facial expressions. The backend server is informed of the associated image URLs while the recorded images are effortlessly transferred to Firebase storage, where they are safely stored. The CNN model is used in the backend, or the brain, of our system to precisely identify emotions from input facial photos. These emotion labels are then conveyed back to the React Native front end via being contained within

JSON requests. The system considers additional contextual information, such as the user's stated age gap, to adjust our approach to the particular preferences and sensitivities of each user. Based on this data, the system uses a sophisticated recommendation technology to offer songs from a personalized music collection that take the user's age gap and the style of music popular in their 20s into account. These musical selections are made in accordance with the identified emotion to provide a unique mood-lifting experience. This approach considers a variety of elements, such as data gathering and preprocessing, model building and training, model integration with the React Native front end, UI design, and performance evaluation. Through this research, we aim to provide valuable insights into the feasibility and effectiveness of personalized emotion-driven music recommendations as a means of enhancing user well-being and satisfaction.

3.1.4. Face recognition

Developing software to assist dementia patients in finding relations by capturing images using face recognition technology is a promising approach to improving their quality of life. The created system would use Neural Network Algorithms to detect and match the faces of individuals in the patient's social gallery with previously stored images and records.

To develop this software, several core functionalities would need to be implemented, including an image recognition system based on machine learning techniques, a database for storing images and personal information, and a user interface that would enable patients to interact with the application with a minimal distraction. Additionally, the system should incorporate text-to-speech library and other assistive technologies to facilitate communication with the patient.

To implement the image recognition system, neural networks (NNs) can be used. These networks have demonstrated excellent performance in facial recognition tasks, with some models achieving near-human levels of accuracy [35] [36] [37].

Once an image is captured, the system would use the neural network to compare it to previously stored images and retrieve all relevant information associated with the individual.

Convolutional neural networks (CNNs) are one of the machine learning methods that are used to find faces in images. The face detection algorithm looks through the image and finds areas where faces are probably to be present. Once faces are detected, the model extracts facial features from the detected faces. It uses a deep neural network to generate a numerical representation, called face encoding or face embedding, for each face. This encoding captures unique characteristics and patterns of the face. To perform face recognition, the model compares the face encodings of the detected faces with the encodings of known faces stored in a database or a list. It computes the similarity between the face encodings using distance metrics such as Euclidean distance. A threshold value is usually set to determine whether two face encodings are considered a match. Based on the computed similarities, the system can identify known faces by finding the closest match(es) to the detected face(s) in the list of known faces. It can also determine if a detected face is unknown if it does not closely match any known face.

The face recognition application in this research uses an AWS S3 bucket to store the images of faces that are used to train and test the face recognition model. This makes it ideal for storing the large number of images that are typically used to train and test face recognition models. AWS S3 is a highly scalable, secure, and durable object storage service that offers a simple web interface to store and retrieve objects. By utilizing AWS S3, which automatically replicates data across several data centers and provides built-in redundancy, we were able to assure the dependability and longevity of our data. The low risk of data loss and high availability provided by this redundancy makes it the perfect option for mission-critical applications like face recognition.
AWS S3, enabling us to quickly upload, download, and manage photographs within the S3 bucket straight from our application.

In terms of security, AWS S3 provided us with various options to protect our data, such as server-side encryption and access control policies. This ensured that our sensitive image data remained confidential and was accessible only by authorized users and services.

The user interface designing should be simple and intuitive for dementia patients [38] for improve the human computer interaction of proposed solution. The interface should include features such as voice output, large fonts, large icons, and simple navigation [38]. Since we are focusing on the dementia patients as the audience of this application, it should be a minimal distractive application.

To evaluate the effectiveness of the system, a randomized trial can be conducted. In this trial, participants would be assigned to the experimental group, which would use the software application. The trial would measure the changes in cognitive function and quality of life in both groups over a specified period.

In conclusion, the proposed system has the ability to significantly improve the quality of life and independence of dementia patients by providing a simple and intuitive way to access information about their social network.

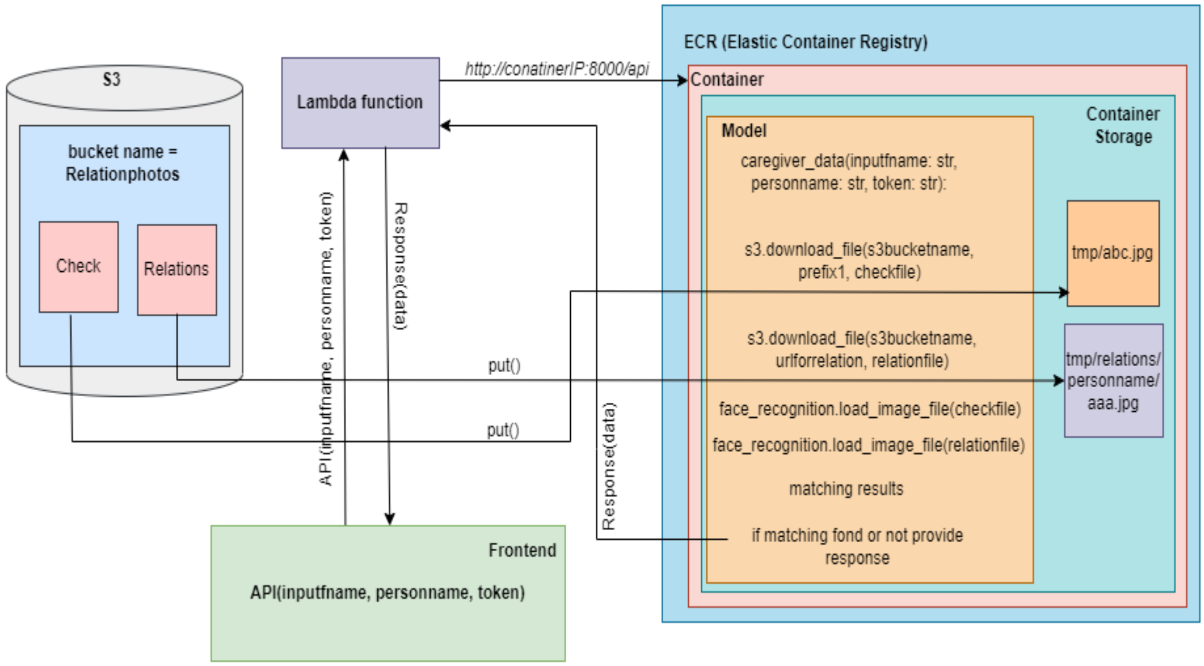


Figure 3.1. 1: In-detail system architecture diagram

In the context of front-end application execution, a complex and orchestrated process unfolds, involving several integral components within a cloud computing environment. Initially, the front-end of the application triggers an API call, serving as the genesis of the computational chain. Subsequently, a Lambda function is activated, commencing the orchestration of operations. This Lambda function, acting as a crucial intermediary, facilitates the transmission of an HTTP request to a container residing within the Amazon Elastic Container Registry (ECR). Within this container, a important phase ensues, wherein a machine learning model is instantiated and set into motion.

One noteworthy facet of this intricate process pertains to data provisioning. Images, critical for subsequent analysis, are sourced from disparate locations within the AWS ecosystem. Images stored within designated Amazon S3 folders are first retrieved, ensuring that pertinent data is ready. Moreover, images residing in the "relations" folder, a separate repository, are also drawn into the container's storage repository within the ECR. This preparatory step is imperative to establish a robust foundation for subsequent computational tasks.

Following the successful data acquisition, the core computational activities commence. The heart of this operation involves the encoding and comparative analysis of the retrieved images. The machine learning model, situated within the container, embarks on a rigorous process of feature extraction, image encoding, and comparative analysis. This multifaceted analytical task culminates in the generation of responses, which are subsequently relayed to the front-end of the application.

As a summary, this comprehensive sequence of actions underscores the intricacy and orchestration inherent to modern cloud-based application architectures. From API initiation to Lambda function invocation, containerized processing, and data acquisition, to the sophisticated image analysis, each step plays a pivotal role in ensuring the provision of timely and accurate responses to the front-end, underscoring the significance of a well-structured and coordinated cloud computing workflow.

3.1.5. System Architecture

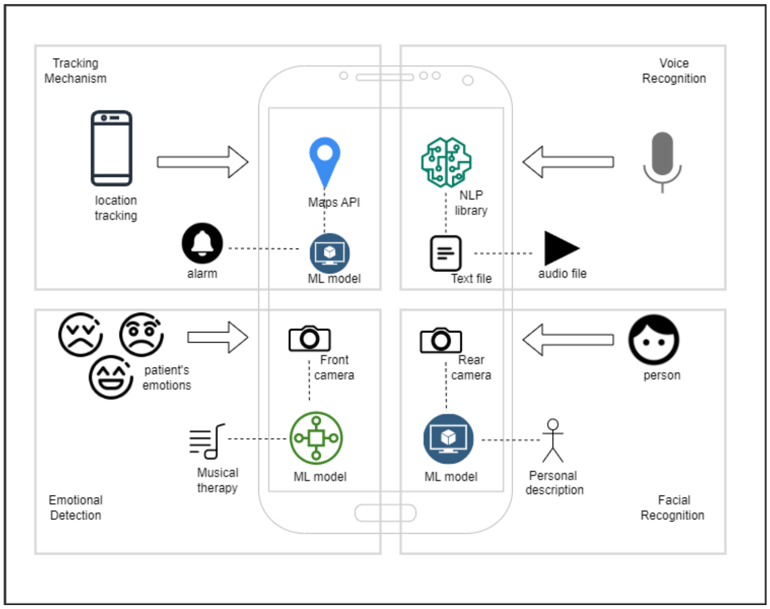


Figure 3.1. 2: Overall system architecture diagram

The above figure illustrates how all the four components are integrated to the mobile application. Relevant technologies have been used to implement each and every functionality.

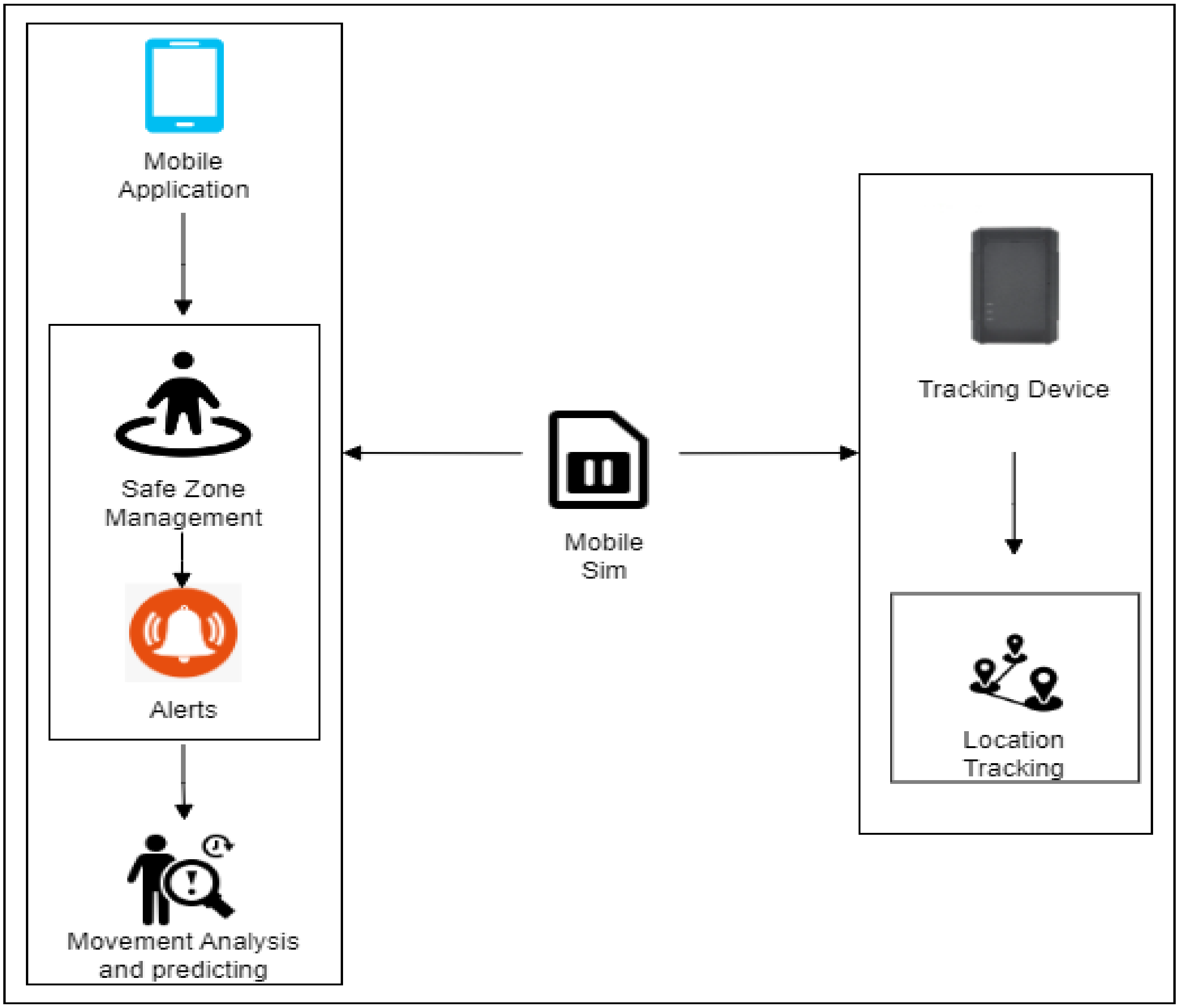


Figure 3.1. 3: Software Diagram of Analyze Wandering and Predict Future Movement Component

This "Analyze wandering and predict future movement" function is part of the system designed to keep dementia sufferers safe from injury and danger. This suggested capability allows carers to keep their attention on the patients, analyze their previous moves, and create safe zones without physically being with them or having a significant impact on their everyday lives.

Figure 3.1.2 shows the adoption of a cutting-edge tracking device designed to assure continuous monitoring and patient safety. This device is a vital companion for the sufferer, and it is always with them. Its connectivity is created by using the device's unique EMEI number, which smoothly connects it to the caregiver's mobile phone. This link is made feasible by activating the device with a mobile SIM card, making it an important component of the patient's safety and well-being.

The tracking device harnesses the extensive reach of cellular networks, tapping into established cellular bands that blanket virtually every corner of the map. These bands facilitate the transmission of signals crucial for keeping tabs on the patient's location and well-being. What sets this system apart is its impressive real-time tracking capability, with the live location of the patient being updated at a remarkable frequency of every 10 seconds. This relentless vigilance ensures that caregivers have up-to-the-minute information at their fingertips, enhancing their ability to respond promptly to any changes or emergencies.

In addition to continuous location tracking, carers have the ability to set safe zones or safety parameters based on the patient's present position. These programmable safety zones operate as virtual limits, adding an extra layer of security. When the patient enters one of these predetermined zones, the system immediately sends notifications to the carers. This dynamic alert system guarantees that caregivers are promptly aware of any deviations from the specified safety parameters, allowing them to take prompt and appropriate action while constantly monitoring the patient.

Furthermore, the system boasts a robust data management component, with every location-related record meticulously stored in the backend of the application. These records serve as a valuable dataset, laying the foundation for the future location prediction functionality of the system depicted in Figure 3.1.2. By harnessing the historical location data, the system can employ advanced algorithms to forecast the patient's future movements and locations, providing caregivers with even greater insights and foresight into their patient's well-being.

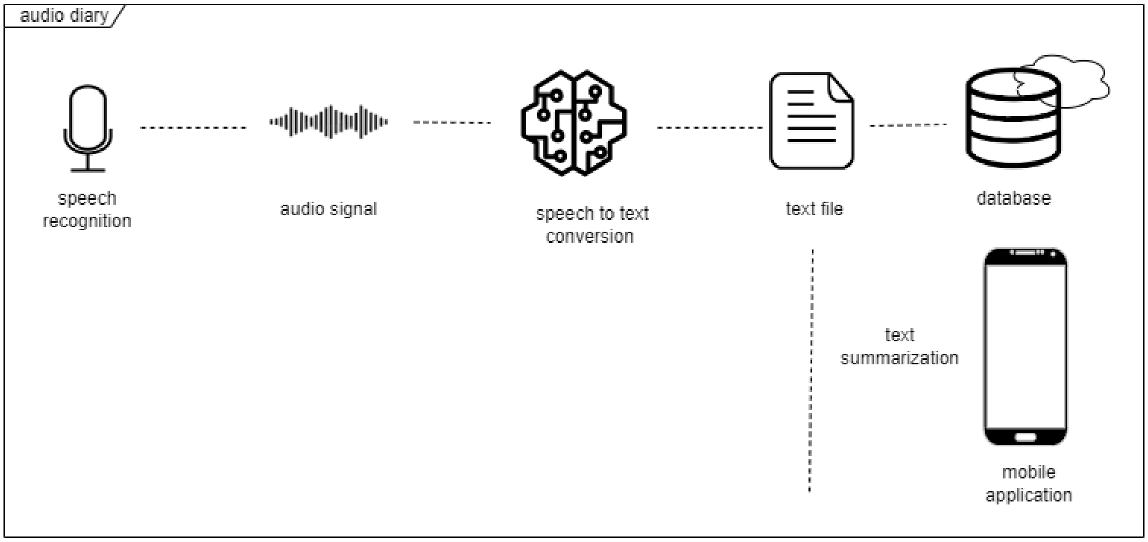


Figure 3.1. 4: Audio diary component

The above diagram illustrates how the audio diary component is being implemented. User's voice is recorded and then it is converted into text format. Both the audio file and the text file are stored in the cloud database to access whenever necessary. The generated text file is used for the summarization purpose.

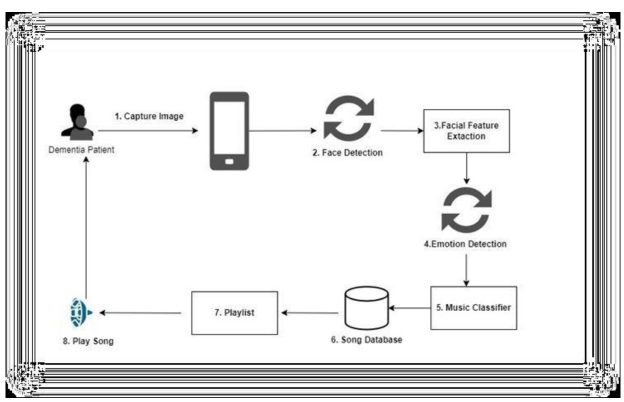


Figure 3.1. 5: Emotion based music player component

Figure 3.1-5 indicates how the emotion-based music player is being implemented and it is very evident that the backend server manages all aspects of image processing while the mobile application handles UIs, gesture control, and all instructions

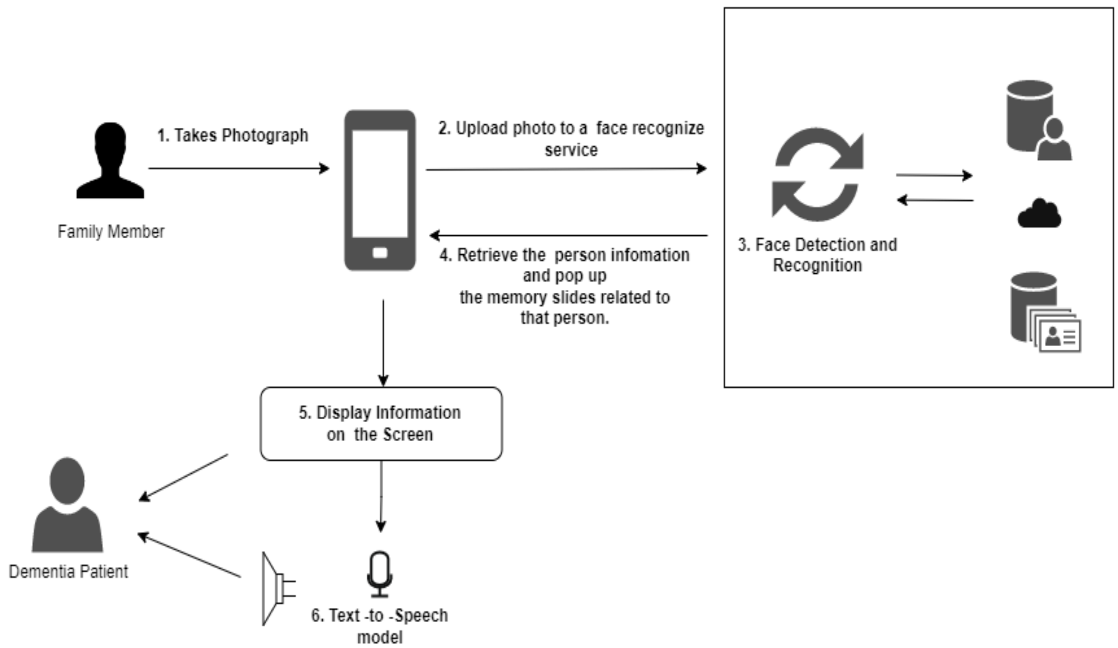


Figure 3.1. 6: Face Recognition System Overview Diagram

Figure 3.1.6 shows the high-level view of the face recognition system. The caregiver can add the relatives and other loved ones of the patient to the system. Therefore, when patient captures the photograph of the person who wants to recognize, the name and the relationship of the person. Also, it gives the voice output of the displayed text messages.

3.1.6. Data collection methods

The initial part of this research project prioritizes information gathering and detailed analysis. This critical stage serves as the foundation for the entire project. We can discover, compile, and organize all of the important criteria for the effective development of the proposed device and system through this rigorous approach.

Initiating this step is imperative and must precede the actual implementation phase. It is during this preparatory period that we laid the groundwork for building a perfect, holistic solution that effectively addresses the challenges associated with dementia care. The requirements gathered during this phase serve as the blueprint for the subsequent stages of the project, guiding its development in a focused and informed manner.

Various methodologies and approaches have been employed to facilitate the requirement gathering process. These methods are designed to ensure that no essential detail or aspect is overlooked. Through comprehensive requirement gathering, we aim to create a solution that not only meets but exceeds the needs and expectations of caregivers and dementia patients alike.

- Read research papers, articles, and journals about wandering.
- Identifying existing tools and devices.
- Conducting a survey to gather information.
- Have physical interviews with caregivers of some patients.

Through a rigorous examination of research papers and scholarly articles, we have meticulously identified and garnered precise insights into the requirements essential for our project. This extensive review of existing literature not only furnished us with a comprehensive understanding of the field but also shed light on the capabilities of current tools and devices. This knowledge proved invaluable in pinpointing the precise research gap that our project seeks to address.

To further enrich our requirement gathering process, we employed a dual approach that included surveys and interviews. These methods were chosen strategically to capture a diverse range of perspectives and ideas. Given the constraints of time, surveys offered an efficient means to collect data and insights from a broader audience. Meanwhile, physical interviews proved indispensable in grounding our research by uncovering requirements at the grassroots level.

We recognized the critical necessity of a vast and diverse dataset in our pursuit of building a strong and highly accurate machine learning model. To accomplish this goal, I formed a tight cooperation with a family and developed a deep connection with them, all with the overall purpose of collecting thorough data on the daily lives and movements of a 62-year-old male dementia patient. This endeavor aimed to generate a large and significant dataset that would serve as the foundation for the accuracy and reliability of our machine learning model.

Over the course of several months, spanning from the 1st of March 2023 to the 30th of June 2023, meticulous efforts were made to meticulously document the patient's travels and locations. This period of data collection was chosen for its substantial timeframe, ensuring that we capture a wide array of experiences and scenarios that the patient encountered. Every place that the patient visited during this timeframe became a data point in our dataset, contributing to the holistic understanding of their movements and routines.

The patient's journey was chronicled with great care and precision. This included details about the places visited, the duration of their stay at each location, and any relevant contextual information. Such comprehensive data was vital not only for the immediate application of the tracking device but also for laying the foundation for a machine learning model that could reliably predict future movements and behaviors.

In essence, the commitment to gathering data for this senior dementia sufferer was both scientific and extremely humanistic. It was motivated by a genuine desire to improve the quality of life for people with cognitive problems and to provide effective tools to carers to ensure their safety and well-being. This dataset, created out of compassion and determination, exemplifies the power of technology to improve the lives of those in need. It is a key resource that will serve as the foundation for the construction of a machine learning model that can truly make a difference in dementia treatment.

The combination of these approaches resulted in a well-rounded and holistic understanding of the needs required for the success of our project. We have laid a solid foundation for our solution by drawing on the viewpoints and experiences of both specialists in the industry and members of the general public. This extensive requirement gathering method has positioned our project to satisfy the needs and ambitions of carers and dementia patients successfully and empathetically.

The CNN/DailyMail dataset, a well-known and useful source for natural language processing tasks, is the main source of data collection for fine-tuning the BART model. This dataset is a great option for improving the model's summarizing abilities because it includes a wide range of news articles and the related human-generated summaries. This text corpus was painstakingly curated and preprocessed as part of the data gathering process to guarantee data quality and relevance. The original source articles and their corresponding abstractive summaries are maintained with special care. The CNN/DailyMail dataset, which has been painstakingly chosen, provides the basis for fine-tuning the BART model and enabling it to succeed in abstractive summarization tasks by learning from the rich and diverse content [39].

The key decision to use the Kaggle FER-2013 dataset for this investigation was motivated by its unique features and applicability to the study's goals. FER-2013 is a thorough and freely accessible database of facial expressions that includes seven different emotional states: anger, disgust, fear, happiness, sorrow, surprise, and neutral. This dataset provides a wide range of emotions, which makes it ideally suited for developing and testing our emotion recognition model.

The core of the data collection process is the utilization of the 'face_recognition' library, a powerful tool for facial recognition tasks. The application employs this library to conduct facial recognition on the downloaded images. This involves comparing each acquired image against a reference image, typically referred to as the 'known image.' The 'known image' serves as a baseline for recognizing individuals. Detected matches during the facial recognition process are meticulously cataloged, capturing various details such as the filenames of the images, URLs pointing to the recognized individuals' photos, and pertinent relationship information. This comprehensive cataloging ensures that the results of the data collection process are well-structured and readily available for further analysis.

Additionally, the recognition parameters can be fine-tuned, allowing the system to be highly versatile and accommodating to various research scenarios. In essence, this data collection and analysis system represents a powerful and flexible tool for data-driven research endeavors, enabling researchers to derive valuable insights from image data with precision and ease.

3.1.7. Tools and Technologies

Tools

- VS code
    - To implement the mobile application
- Postman

    To test the mobile application
- Google Colab
    - To finetune the BART model

- Kaggle Notebook
    - To train the machine learning models
- Docker
    - To create a container image.
- Google Colab – Used to train and run machine learning models using cloud resources.
- Jupyter Notebook – Used to train and run the machine learning models locally.
- VT03D Portable Tracking Device – To track patients' locations and map related features.
- Expo-CLI – Used to install expo libraries to react-native applications.

Technologies

- React native
    - Used to implement mobile application
- Firebase
    - Used to implement the database
- FastAPI
    - To implement the backend API for the mobile application
- TensorFlow
- Keras
- Mangum
    - Used to deployment on AWS Lambda
- Urllib3
    - Used for making HTTP requests, handling, and managing connection.
- AWS Lambda
    - Used for creating a secure URL communicate between frontend and AWS container

- AWS Amplify
    - Used for uploading images to AWS S3 buckets. That is a framework.
- Uvicorn
- Expo – A set of tools and services that makes the app development and build process much easier.
- Python – The language used to implement the backend including the ML models.
- Google Map API – For map implementations and configurations.

Table 3. 1: External tools

Description	**Tools**
Version Controlling	Gitlab
Team connectivity	Teams, WhatsApp

3.2. Commercialization aspects of the product

In our pursuit of commercializing our mobile application, which holds immense potential to benefit individuals worldwide, we recognize the need for a multifaceted approach that aligns with current global trends and user behaviors. Given that our application operates in the international language of English, its reach extends far beyond the borders of Sri Lanka, making it accessible and relevant to a global audience. To ensure swift and widespread adoption, we have strategically identified several key avenues for commercialization, with a primary focus on harnessing the immense power of social media platforms.

In today's digital landscape, social media stands out as a dynamic and influential force. With millions of users spending a substantial portion of their daily lives on platforms such as Facebook, WhatsApp, Instagram, and YouTube, leveraging these channels for advertising and promotion is not only prudent but essential. Through targeted and engaging adverts on these platforms, we can effectively introduce our application to a vast and diverse consumer base, transcending geographical boundaries.

Furthermore, we have recognized the importance of content providers in shaping trends and boosting user engagement. Platforms like YouTube, Twitch, and Trovo are home to a growing community of content creators with large followings. By selectively sponsoring and supporting these influencers, we can use their reach and influence to raise awareness about our system within their respective communities. This spontaneous recommendation can help us create confidence and credibility for our application.

To broaden our reach, we intend to work closely with healthcare organizations such as hospitals and clinics. Within their particular communities, these institutions provide reliable sources of knowledge and care. We can design targeted awareness programs that appeal to both healthcare professionals and patients by collaborating with them. This strategy ensures that our application reaches people from all walks of life, regardless of financial status.

We recognize the lasting power of conventional media in addition to digital platforms. For example, leaflets can be a useful instrument for increasing public awareness of our product, particularly within rural communities. We also recognize the importance of radio and podcasts, which continue to have a loyal following. Sponsoring radio shows and podcasts that cater to our target audience can be a beneficial outlet for advertising our product and its benefits.

3.3. Project requirements

3.3.1. Functional requirements

- The system should be able to convert speech to text.
- The system must be compatible with the language support and vocabulary support.
- The system must be implemented considering the context awareness.
- The system must be compatible with the integration.
- The system should generate the summary analyzing the text generated.
- Extract data from the image
- Identify the person who is captured.
- Provide a description of the captured person.
- Display the memory with that person.
- Provide voice output of the details that are displayed on the screen.
- Identify and monitor the patient's location.
- Identify and establish correct safe zones upon the caregiver's input.
- Maintain historical records separately.
- Predict the patient's future movements.
- Constantly monitor the patient's location.

3.3.2. Non-functional requirements

- Performance - the application needs to be optimized for mobile platforms that dementia patients frequently use. This entails making sure the application is snappy, launches quickly, and uses minimal data or energy.
- Scalability - The application should be able to handle increased traffic and usage when more dementia sufferers start using it without slowing down or crashing. This could entail making the application responsive on various mobile device types and making sure the backend infrastructure can support the added demand.

- Security - The program should be created with straightforward and efficient security features because dementia sufferers may have trouble understanding or remembering sophisticated security procedures. This may involve taking steps like data encryption, auto-logouts, and biometric authentication.
- Reliability - The application should be made to function consistently and dependably, even in challenging circumstances. This might include attributes like offline functionality, error handling, and automatic data backups.
- Maintainability - Even when new features are added or the application is modified for new mobile device kinds, the application should be simple to maintain and update. This could involve using modular components, comprehensive documentation, and well-structured code in the design of the application.
- Accuracy - This is a key feature since one of the complaints from users is most of the existing applications are not accurate. It is important to show real-time data.
- Usability - This is a key feature since one of the complaints from users is most of the existing applications are not accurate. It is important to show real-time data.
- Accessibility – Device and necessary instructions will be provided. The user only needs to have a smartphone.
- Well optimized – The device needs to be optimized well with the proposed system for the user to have a pleasant experience while using the mobile application.

3.3.3. User requirements

- This mobile application must be installed to the user’s smart phone.
- User should have basic knowledge in English language.
- User should have an understanding about how to use a simple mobile application.

3.4. Testing and Implementation

3.4.1. Implementation

The system implementation is done by focusing on the frontend and backend separately. As discussed previously, the development process includes the implementation of the below functionalities to accomplish all the identified requirements.

- An android mobile application using React native as the front-end technology.
- Implementation of profile sections for both dementia patients and caregivers.
- Implementation of a location tracking mechanism.
- Designing a model to predict locations.
- Implementation of safe zones and alerting system
- A mechanism to track a patient’s movement history.
- Implementation of a voice recognition system alongside voice to text conversion.
- Designing a text summarization model to summarize the content.
- A mechanism to access daily diary records using a calendar.
- Designing the Emotion detection model
- Designing the music library respective to the age gap and the emotions
- Implementation of face recognition model
- Implementation of text to speech library

Our system's implementation is a methodically planned endeavor that leans heavily on the abundance of knowledge we have already accumulated. Our strategy revolves around the incorporation of current products and technology that contribute directly or indirectly to the realization of the proposed system. We intend to make the required connections with various devices, tools, and systems to produce a smooth and comprehensive solution by expanding on this base and systematically improving functions.

The use of pre-existing devices and technology is one of the primary guiding principles of our execution strategy. This method not only speeds up the development process, but it also ensures that we capitalize on established standards and best practices. By doing so, we hope to solve some of the most common complaints stated by users of existing devices on the market, such as difficulties with accuracy, cost, and complexity.

In response to these common customer issues, we put a major emphasis on enhancing accuracy, cost-effectiveness, and user-friendliness during the deployment process. We are devoted to improving and refining our system's tracking capabilities in order to present users with the most accurate and reliable information available. At the same time, we are conscious of cost considerations and seek to provide a solution that is not only accessible but also cost-effective.

To start this implementation journey, we initiated a comprehensive requirement analysis. This crucial step allowed us to gather and document all the essential requirements that will guide the development process. These requirements serve as our blueprint, outlining the features, functionalities, and performance expectations of the system. They represent the foundation upon which we build a solution that not only meets but exceeds the needs and expectations of our users.

For the implementations of the map interfaces, it consists of both server side and client-side implementations, client-side implementations mean the mobile application and the server-side implementation means the allowing users to user map related functionalities such as geofencing and routing. React Native has been used to develop mobile applications while map services are called using Google map API. It has been developed to show the live locations and live movements of the person with the tracking device.

```
const END_POINT =
  "https://6bc9-2402-d000-8130-51be-f9df-fe08-d08b-5577.ngrok-free.app"; // Replace with your server's URL
import axios from "axios";

export const API_KEY = "AIzaSyByO8RKhNqjGYw4LnknmMqwxyyyOqKQ9G8";

const api = axios.create({
  baseURL: END_POINT, // Replace with your server's URL
  timeout: 10000, // Adjust the timeout as needed
});

export default api;
```

Figure 3.4. 1: Usage of Google Map API to implement functions.

```
const geocode = async () => {
  const geocodeLocation = await Location.geocodeAsync(address);
  console.log("geolocation:", geocodeLocation);
};

const reverseGeocodeAsync = async () => {…
};

const requestLocationPermission = async () => {…
};

const getCurrentPosition = async () => {
  const { status } = await Location.requestForegroundPermissionsAsync();
  if (status !== "granted") {
    console.log("Location permission denied!");
    return;
  }

  try {
    const location = await Location.getCurrentPositionAsync({});
    const { latitude, longitude } = location.coords;
    setLatu(parseFloat(latitude));
    setLong(parseFloat(longitude));
    console.log("Current position:", latitude, longitude);
    console.log("Location:", location);
  } catch (error) {
    console.log("Error getting location:", error);
  }
};

const onRegionChange = (region) => {
  console.log("region :", region);
};

useEffect(() => {
  getCurrentPosition();
}, []);
```

Figure 3.4. 2: Display current location.

I have used the sophisticated geofencing and geocoding facilities generously supplied by the Google Maps API to create safe zones and dynamically alter them based on the user's current location. This feature allows users to define safe zones by entering particular geographical coordinates (latitude and longitude) for each chosen location. These coordinates are carefully recorded, resulting in a map-based digital representation of each established safe zone.

Users are reminded to define a minimum of three and a maximum of four sites to ensure the usefulness of this safety feature. This thoughtful limitation not only improves the tool's utility but also aligns with practical reasons for ensuring a high level of security and accuracy. Once these safe zones are recognized and recorded by their coordinates, they are integrated into the larger geographical environment, thus creating digital borders within the physical world.

```
const showLocationInterest = () => {
  return locationInterest.map((item, index) => {
    return (
      <Marker
        key={index}
        coordinate={item.location}
        title={item.title}
        description={item.description}
      />
    );
  });
};

const geocode = async () => {
  const geocodeLocation = await Location.geocodeAsync(address);
  console.log("geolocation:", geocodeLocation);
};

const reverseGeocodeAsync = async () => {
  try {
    const latitude = parseFloat(latu);
    const longitude = parseFloat(long);
    console.log("latitude:", latitude);
    console.log("longitude:", longitude);
    const location = await Location.reverseGeocodeAsync({
      latitude,
      longitude,
    });
    console.log("Reverse geocoded location:", location);
  } catch (error) {
    console.log("Error during reverse geocoding:", error);
  }
};
```

Figure 3.4. 3: Geofencing/Geocoding services

Predefined safe zones serve as virtual safeguards, allowing the system to continuously monitor the user's location and trigger alerts or actions when they enter or exit these predefined safe zones. Text messages are sent to the caregivers registered mobile phone constantly while tracking the live location of the patient despite the emergency.

```
import Twilio from 'react-native-twilio';

const sendSMS = (message) => {
  Twilio.initWithToken('YOUR_TWILIO_ACCOUNT_SID', 'YOUR_TWILIO_AUTH_TOKEN');

  Twilio.sendMessage({
    body: message,
    to: 'RECIPIENT_PHONE_NUMBER',
    from: 'TWILIO_PHONE_NUMBER',
  }).then((result) => {
    // Handle the SMS sending result
  });
};
```

Figure 3.4. 4: Triggering alerts as messages and sending to the caregivers.

Machine Learning Models

- **Decision Tree Algorithm**

At first, while doing tracking device related tasks, I closely associated with a family and gathered data for 4 months and built a data. The Decision Tree algorithm was implemented first in order to predict locations. The following steps are implemented in order to build a successful model.

- **Importing libraries and loading dataset**

```python
# Import necessary libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, confusion_matrix, ConfusionMatrixDisplay

data = pd.read_csv("Datasets/Dataset_Locations.csv")
data.head(5)
```

	Date	Day of the Week	Time of the Day	Reason	Location
0	3/1/2023	Wednesday	Morning	Normal routine	Home
1	3/1/2023	Wednesday	Morning	Daily Chores	Home
2	3/1/2023	Wednesday	Morning	Personal Habit	Backyard
3	3/1/2023	Wednesday	Morning	Daily Morning Visit	Garden
4	3/1/2023	Wednesday	Morning	Breakfast	Home

Figure 3.4. 5: Imported libraries for Decision Tree Algorithm

This section imports necessary libraries for data manipulation, visualization, and machine learning. It also loads a dataset named "Dataset_Locations.csv" using Pandas and displays the first 5 rows of the dataset.

- **Data preprocessing**

```
[ ]  data = data[~(data['Date'] == 0)]
     data = data[~(data['Day of the Week'] == 0)]
     data = data[~(data['Time of the Day'] == 0)]
     data = data[~(data['Location'] == 0)]
     data = data[~(data['Reason'] == 0)]
```

```
[ ]  data.shape

     (4395, 5)
```

```
[ ]  # remove null values
     null_rows = data.isnull().any(axis=1)  # Check if any value in each row is null
     data = data[~(null_rows)]
     data.shape

     (4100, 5)
```

```
[ ]  # remove dupicates rows

     # Remove duplicate rows
     data = data.drop_duplicates(subset=['Date', 'Day of the Week', 'Time of the Day', 'Location', 'Reason'])

     # Print the DataFrame without duplicates
     print(data)
     data.shape

                Date Day of the Week Time of the Day              Reason  \
     0      3/1/2023       Wednesday         Morning      Normal routine
     1      3/1/2023       Wednesday         Morning        Daily Chores
     2      3/1/2023       Wednesday         Morning      Personal Habit
     3      3/1/2023       Wednesday         Morning  Daily Morning Visit
     4      3/1/2023       Wednesday         Morning           Breakfast
     ...         ...             ...             ...                 ...
```

Figure 3.4. 6: Data preprocessing of Decision Tree Algorithm

In this section, various data preprocessing steps are performed. Rows with specific conditions (e.g., Date, Day of the Week, Time of the Day, Location, and Reason equal to 0) are removed. Rows with any null values are removed. Duplicate rows based on specific columns are dropped.

- **Data visualization**

```
[ ]  locations = data['Location'].value_counts()
     print((locations))

     Home                            1808
     Garden                           543
     Backyard                         241
     Paddy Fields                     186
     Home                             119
                                    ...
     Matara Town                        1
     Relatives House - Garden           1
     Hiriketiya Junction                1
     Nupe Junction                      1
     pubb                               1
     Name: Location, Length: 79, dtype: int64

[ ]  # Increase the width of the graph
     plt.figure(figsize=(20, 8))

     data['Location'].value_counts().plot()
     plt.show()
```

Figure 3.4. 7: Visualizing the data for Decision Tree Algorithm

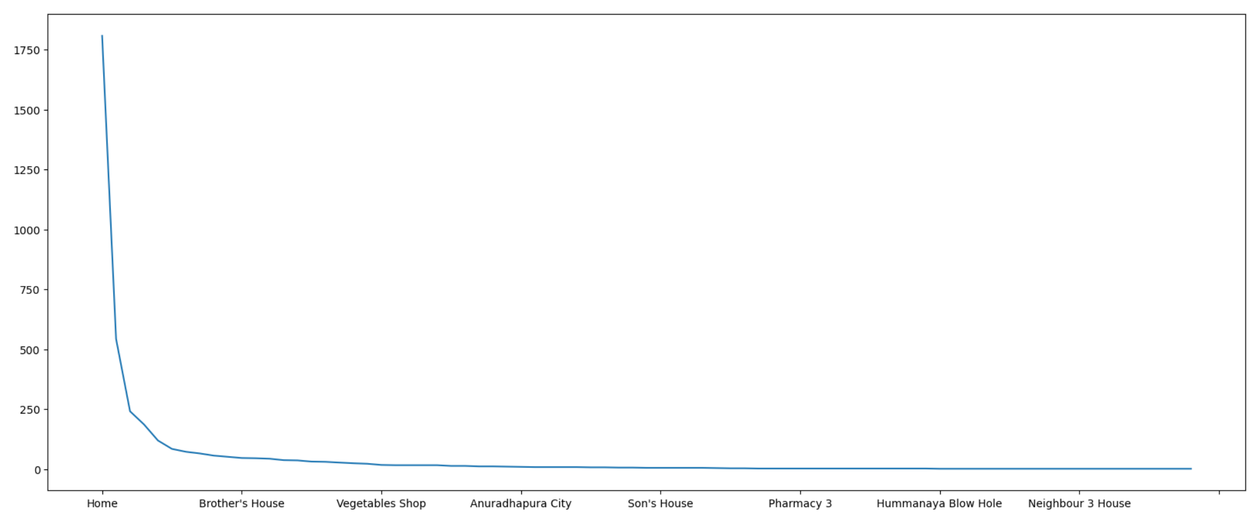
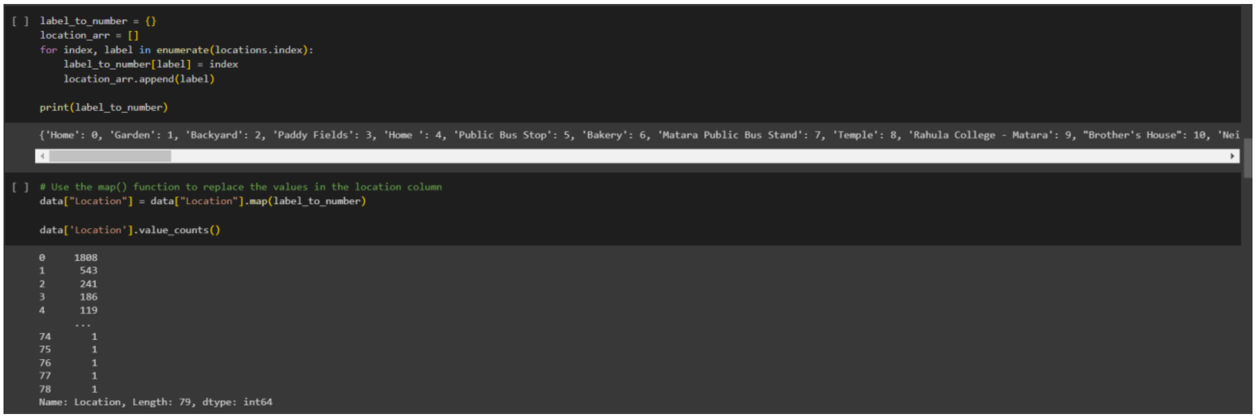


Figure 3.4. 8: Plotting the data of Decision Tree Algorithm

This section explores and visualizes the distribution of Location values in the dataset. It calculates the count of each unique Location value and plots a bar chart to visualize the distribution.

- **Feature Engineering**



```
[ ] label_to_number = {}
    location_arr = []
    for index, label in enumerate(locations.index):
        label_to_number[label] = index
        location_arr.append(label)

    print(label_to_number)

    {'Home': 0, 'Garden': 1, 'Backyard': 2, 'Paddy Fields': 3, 'Home ': 4, 'Public Bus Stop': 5, 'Bakery': 6, 'Matara Public Bus Stand': 7, 'Temple': 8, 'Rahula College - Matara': 9, "Brother's House": 10, 'Nei

[ ] # Use the map() function to replace the values in the location column
    data["Location"] = data["Location"].map(label_to_number)

    data['Location'].value_counts()

    0     1808
    1      543
    2      241
    3      186
    4      119
          ...
    74       1
    75       1
    76       1
    77       1
    78       1
    Name: Location, Length: 79, dtype: int64
```

Figure 3.4. 9: Feature Engineering of Decision Tree Algorithm

In this section, feature engineering is performed on the dataset. Location, Reason, Time of the Day, and Day of the Week columns are mapped to numeric values.

- **Training and evaluating the model.**

```
# Split the dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)
```

```
def model_executor_and_acuracy(model):
    # Train the model on the training data
    model.fit(X_train, y_train)

    # Make predictions on the test data
    y_pred = model.predict(X_test)

    print(f"<<<<====== {model} ====>>>>")
    # Calculate the accuracy of the model
    accuracy = accuracy_score(y_test, y_pred)
    print("Accuracy:", accuracy)
```

```
# Create a logistic regression model
logreg = LogisticRegression()
# Create a KNeighborsClassifier model
knc = KNeighborsClassifier(n_neighbors=2)
# Create a DecisionTreeClassifier model
dtc = DecisionTreeClassifier()
models = [logreg, dtc, knc]
```

Figure 3.4. 10: Training and evaluating the various models.

In this section, the dataset is split into features (X) and the target variable (y). Three different machine learning models (Logistic Regression, Decision Tree, K-Nearest Neighbors) are created and evaluated for accuracy. According to this, I have got an accuracy y of 94.16 for the Decision Tree algorithm.

- **Making predictions**

```
from datetime import datetime

date = "3/5/2023"
day_of_week = "Sunday"
time_of_day = "Morning"
s_reason = "Medicine"

numeric_date = pd.to_datetime(date, format='%m/%d/%Y')
numeric_date = (numeric_date - pd.Timestamp('1970-01-01')).days

day_of_week = week_day_mapping[day_of_week]
time_of_day = day_mapping[time_of_day]

if s_reason in reason_to_number:
    s_reason = reason_to_number[s_reason]
else:
    s_reason = len(reason_to_number)

df = pd.DataFrame({'Date': [numeric_date], 'Day of the Week': [day_of_week], 'Time of the Day': [time_of_day], 'Reason': [s_reason]})

sample = df.iloc[:,:].values

predict_res = load_mode.predict(sample)
print('predic', predict_res)
print("Predict Location : ", location_arr[predict_res[0]])
```

Figure 3.4. 11: Making predictions using Decision Tree Algorithm

In this section, a sample input is created for prediction, where the user provides a date, day of the week, time of day, and reason. This input is then converted to a numeric format, and the loaded Decision Tree model is used to make a location prediction based on the input. The predicted location is displayed.

➢ **Random Forest Algorithm**

After finishing the configurations with the tracking device, it was suggested that with the data that are been saved from the device cannot be trained by a decision tree algorithm since it captures the latitude and longitude of the location. So after doing further analysis, it was evident that Random Forest Algorithm is recommended for those kind of scenarios. To build that ML model, the following steps have been implemented.

- **Importing libraries and loading dataset**

```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor
from sklearn.metrics import mean_absolute_error, mean_squared_error

# Load the CSV file into a Pandas DataFrame
csv_file_path = 'gpsdata.csv'
df_csv = pd.read_csv(csv_file_path)
```

Figure 3.4. 12: Importing libraries to Random Forest Algorithm

In this section, necessary libraries are imported. Pandas is used for data manipulation, train_test_split for splitting data, RandomForestRegressor for building a random forest regression model, and mean_absolute_error and mean_squared_error for evaluating model performance. Then a CSV file named 'gpsdata.csv' has been loaded into a Pandas DataFrame.

- **Data cleaning**

```
# Skip irrelevant rows and keep only relevant columns
df_clean = df_csv.iloc[2:].reset_index(drop=True)
df_clean.columns = df_csv.iloc[1]
```

Figure 3.4. 13: Cleaning data from Random Forest Algorithm

This section skips the first two rows (which are irrelevant) and resets the index. The column names are set to the values from the third row, which presumably contain column headers.

- **Data preprocessing**

```
# Convert columns df_clean['GPS Time'] = pd.to_datetime(df_clean['GPS Time'])
df_clean['Latitude'] = pd.to_numeric(df_clean['Latitude'], errors='coerce')
df_clean['Longitude'] = pd.to_numeric(df_clean['Longitude'], errors='coerce')

# Identify the data type of 'GPS Time'
print(df_clean['GPS Time'].dtype)

object

# Convert object data type to date-time
df_clean['GPS Time'] = pd.to_datetime(df_clean['GPS Time'])
```

Figure 3.4. 14: Data preprocessing of Random Forest Algorithm

Here, data preprocessing is performed. The 'GPS Time' column is converted to datetime format. The 'Latitude' and 'Longitude' columns are converted to numeric format, and any parsing errors are set to NaN using the errors='coerce' argument.

- **Extracting date time components**

```
# Extract year, month, day, hour, minute, and second from the 'GPS Time' column
df_clean['year'] = df_clean['GPS Time'].dt.year
df_clean['month'] = df_clean['GPS Time'].dt.month
df_clean['day'] = df_clean['GPS Time'].dt.day
df_clean['hour'] = df_clean['GPS Time'].dt.hour
df_clean['minute'] = df_clean['GPS Time'].dt.minute
df_clean['second'] = df_clean['GPS Time'].dt.second
```

Figure 3.4. 15: Extracting components in Random Forest Algorithm

This part extracts year, month, day, hour, minute, and second components from the 'GPS Time' column and creates new columns for each component in the DataFrame.

- **Defining features and target variables**

```
# Features and target variables
features = ['year', 'month', 'day', 'hour', 'minute', 'second']
target_latitude = 'Latitude'
target_longitude = 'Longitude'
```

Figure 3.4. 16: Defining features and target variables in Random Forest Algorithm

Here, the features for the regression model are defined as the extracted date and time components. The target variables are set as 'Latitude' and 'Longitude' columns.

- **Splitting the data in to training and testing datasets**

```
# Split data into training and test sets
X = df_clean[features]
y_latitude = df_clean[target_latitude]
y_longitude = df_clean[target_longitude]

X_train_lat, X_test_lat, y_train_lat, y_test_lat = train_test_split(X, y_latitude, test_size=0.2, random_state=42)
X_train_long, X_test_long, y_train_long, y_test_long = train_test_split(X, y_longitude, test_size=0.2, random_state=42)
```

Figure 3.4. 17: Splitting data to training and testing in Random Forest Algorithm

This section splits the data into training and test sets separately for latitude and longitude predictions using the train_test_split function. A random seed is set to ensure reproducibility.

- **Initializing and training Random Forest model**

```
# Initialize and train the Random Forest models
rf_model_lat = RandomForestRegressor(random_state=42)
rf_model_long = RandomForestRegressor(random_state=42)

rf_model_lat.fit(X_train_lat, y_train_lat)
rf_model_long.fit(X_train_long, y_train_long)
```

Figure 3.4. 18: Initializing the Random Forest Algorithm

Two Random Forest Regressor models are initialized and trained separately for latitude and longitude using the training data.

- **Making sample predictions**

```
# Make a sample prediction for a given datetime
sample_datetime = pd.DataFrame({
    'year': [2023],
    'month': [9],
    'day': [1],
    'hour': [10],
    'minute': [0],
    'second': [0]
})

predicted_latitude = rf_model_lat.predict(sample_datetime)
predicted_longitude = rf_model_long.predict(sample_datetime)

print(f"Predicted Latitude: {predicted_latitude[0]}")
print(f"Predicted Longitude: {predicted_longitude[0]}")

Predicted Latitude: 8.006238390000004
Predicted Longitude: 80.91337976999996
```

Figure 3.4. 19: Making Sample predictions in Random Forest Algorithm

This code essentially demonstrates how to load and preprocess GPS data, train random forest regression models for latitude and longitude prediction and make a sample prediction using these models.

The following methodology was used to develop the frontend part of implementing the audio diary component in order to deliver a seamless efficient user experience:

- A react native app was built as the front end with utilizing Expo Go as the runtime environment.
- All the user interfaces were designed and implemented once the React Native app was set up with the necessary configurations.
- Lastly, an API connection was made between the front end and the back end to enable the execution of machine-learning models.

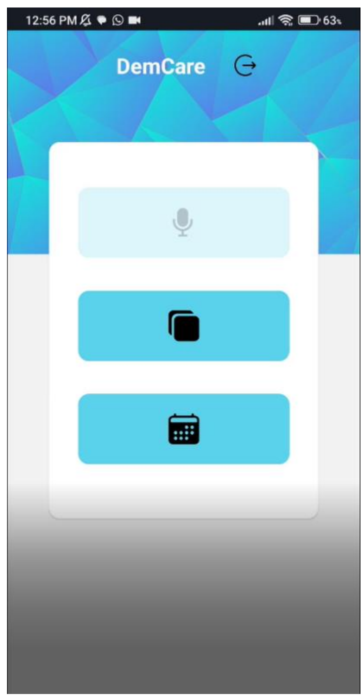


Figure 3.4. 20: UI of audio diary component

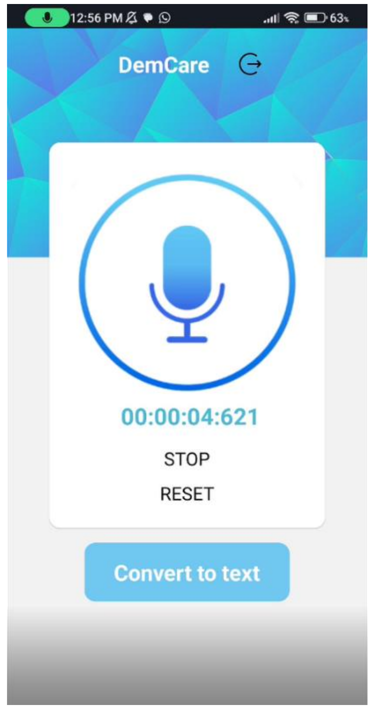


Figure 3.4. 21: UI of voice recorder

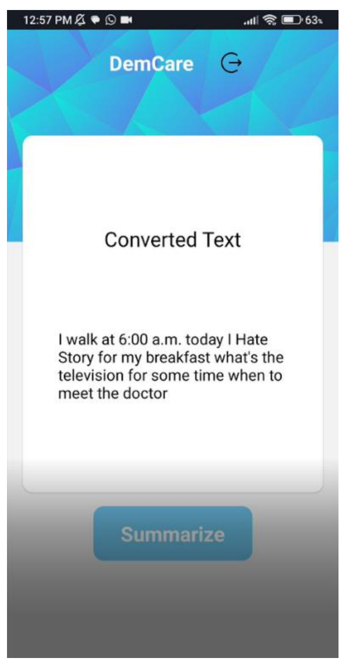


Figure 3.4. 22: UI of converted text

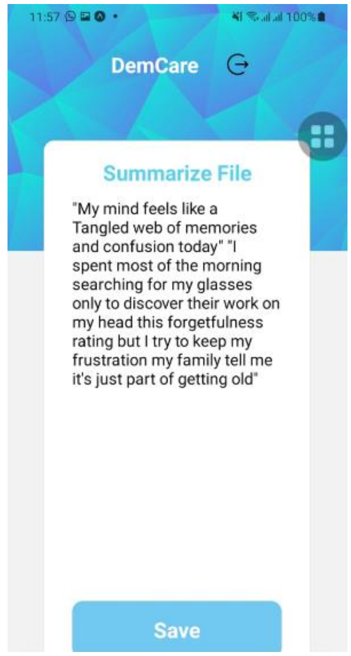


Figure 3.4. 23: UI of summarized text

Back end implementation for this research component includes fine tunining the BART model and implementing the text summarization mechanism.

Several crucial steps must be taken in order to perfect the BART model from Hugging Face for text summary. The pre-trained BART model and tokenizer must be loaded first. To train the model, one must then obtain a sufficient dataset, frequently in a structured manner. The dataset typically consists of text data pairs with the source text (for example, articles) and destination text (for example, summaries) being the same.

Data preprocessing follows, including tasks such as tokenization and formatting the data into input-target pairs. This ensures that the model can understand and learn to generate summaries effectively. Subsequently, the dataset is split into training and validation sets to evaluate the model's performance during training.

The batch size, number of training epochs, and assessment procedures are only a few examples of the training parameters and arguments that must be specified. It is common practice to prepare the data for training using a data collator tailored to sequence-to-sequence tasks. This collator handles operations like padding and token-to-number conversion.

Throughout training, model checkpoints can be saved to ensure that the fine-tuning process can be resumed or evaluated later. Additionally, evaluation metrics are used to assess the model's performance on the validation set, helping to monitor progress and identify potential overfitting.

The model can be stored for future use after the fine-tuning procedure is finished. It may be used to create summaries for fresh text input, making it a useful tool for information extraction and content summarization. Therefore, fine-tuning the BART model is a structured method of modifying a potent pre-trained model for the particular purpose of text summarization.

```
# Import necessary libraries
import os
import torch
!pip install transformers
from transformers import BartTokenizer, BartForConditionalGeneration, BartConfig
from torch.utils.data import Dataset, DataLoader
from sklearn.model_selection import train_test_split
from tqdm import tqdm
import pandas as pd
```

Figure 3.4. 24: Code snippet of importing libraries into google colab

```
[ ] # Load and preprocess the dataset
    df_train = pd.read_csv(train_file)
    df_valid = pd.read_csv(valid_file)
    df_train
    df_valid
```

	Unnamed: 0	article	highlights	id
0	0	It's official: U.S. President Barack Obama wan...	Syrian official: Obama climbed to the top of t...	0001d1afc246a7964130f43ae940af6bc6c57f01
1	1	(CNN) -- Usain Bolt rounded off the world cham...	Usain Bolt wins third gold of world championsh...	0002095e55fcbd3a2f366d9bf92a95433dc305ef
2	2	Kansas City, Missouri (CNN) -- The General Ser...	The employee in agency's Kansas City office is...	00027e965c8264c35cc1bc55556db388da82b07f
3	3	Los Angeles (CNN) -- A medical doctor in Vanco...	NEW: A Canadian doctor says she was part of a ...	0002c17436637c4fe1837c935c04de47adb18e9a
4	4	(CNN) -- Police arrested another teen Thursday...	Another arrest made in gang rape outside Calif...	0003ad6ef0c37534f80b55b4235108024b407f0b
...	...	...	...	...
9995	95	President Barack Obama signed an executive ord...	Executive order bars contractors covers LGBT e...	004e6e935ea530b0992a89fd1307f7f41f4a234d
9996	96	Editor's note: This is an excerpt from the Feb...	In rural Africa, there is love for soccer but ...	004f0f8c694c4b546b29565a8993a555537ff561
9997	97	(CNN) -- The International Olympic Committee h...	It's the first time a ban of a national commit...	004fc12e7cd2505a013d96e816afae3f3ce5015d
9998	98	(Mother Nature Network) -- Mother's Day poems ...	Poets have long written about their mothers or...	00504275ede73591d94a6c1f994fd4856610421c
9999	99	LONDON, England (CNN) -- When Danish auteur La...	Pornographic sex and visceral violence in "Ant...	00512126d65bf2a36801e4ef37f28c86c29deb28

Figure 3.4. 25: Loading dataset in google colab

```
[ ] # Split data into train and validation sets
    train_texts = df_train["article"].tolist()
    train_summaries = df_train["highlights"].tolist()
    valid_texts = df_valid["article"].tolist()
    valid_summaries = df_valid["highlights"].tolist()
```

Figure 3.4. 26: Splitting data

```
[ ] # Tokenize the data
    tokenizer = BartTokenizer.from_pretrained("facebook/bart-large-cnn")
    train_encodings = tokenizer(train_texts, truncation=True, padding=True, max_length=1024, return_tensors="pt", add_special_tokens=True)
    train_labels = tokenizer(train_summaries, truncation=True, padding=True, max_length=150, return_tensors="pt", add_special_tokens=True)
    valid_encodings = tokenizer(valid_texts, truncation=True, padding=True, max_length=1024, return_tensors="pt", add_special_tokens=True)
    valid_labels = tokenizer(valid_summaries, truncation=True, padding=True, max_length=150, return_tensors="pt", add_special_tokens=True)
```

Figure 3.4. 27: Tokenizing data

```
[ ] # Create a custom PyTorch dataset
    class SummarizationDataset(Dataset):
        def __init__(self, encodings, labels):
            self.encodings = encodings
            self.labels = labels

        def __len__(self):
            return len(self.encodings["input_ids"])

        def __getitem__(self, idx):
            item = {key: val[idx] for key, val in self.encodings.items()}
            item["labels"] = self.labels["input_ids"][idx]  # Use "labels" key for labels
            return item

    train_dataset = SummarizationDataset(train_encodings, train_labels)
    valid_dataset = SummarizationDataset(valid_encodings, valid_labels)
```

Figure 3.4. 28: Creating custom dataset.

```
[ ] # Initialize the model and training parameters
    model = BartForConditionalGeneration.from_pretrained("facebook/bart-large-cnn")
    device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
    model.to(device)
    model.train()
```

Figure 3.4. 29: Initializing the model.

```
[ ] # Define training parameters
    train_batch_size = 4
    valid_batch_size = 4
    num_train_epochs = 1
    learning_rate = 3e-5
```

Figure 3.4. 30: Defining training parameters

```
# Training loop
for epoch in range(num_train_epochs):
    model.train()
    train_loss = 0.0

    for batch in tqdm(train_loader, desc=f"Epoch {epoch}"):
        optimizer.zero_grad()
        input_ids = batch["input_ids"].to(device)
        attention_mask = batch["attention_mask"].to(device)
        labels = batch["labels"].to(device)
        # input_ids = batch["input_ids"]
        # attention_mask = batch["attention_mask"]
        # labels = batch["labels"]

        outputs = model(input_ids, attention_mask=attention_mask, labels=labels)
        loss = outputs.loss
        loss.backward()
        optimizer.step()
        train_loss += loss.item()

    # Print training loss for this epoch
    print(f"Epoch {epoch}: Train Loss: {train_loss / len(train_loader)}")
```

Figure 3.4. 31: Training loop with epoches

```
# Save the fine-tuned model
output_dir = "fine_tuned_bart"
os.makedirs(output_dir, exist_ok=True)
model.save_pretrained(output_dir)
tokenizer.save_pretrained(output_dir)
```

Figure 3.4. 32: saving the model

After the model was saved a docker container must be created to encapsulate the model and its dependencies. This containerization ensures portability and scalability. Once the Docker image is built, it can be hosted on a server or cloud platform, making it accessible over the internet.

To integrate the model into the mobile app, need to develop an API endpoint within the

Docker container that accepts text input and responds with generated summaries. The mobile app can then send requests to this API to obtain summarization services.

services > JS summarize_service.jsx > ...

```
export const getSummaries = async (date) => {
  let summaries = [];
  const db = getFirestore(db);
  const q = query(
    collection(db, "summaries"),
    where("summered_by", "==", auth.currentUser.uid),
    where("date", "==", date)
  );
  const querySnapshot = await getDocs(q);
  querySnapshot.forEach((doc) => {
    summaries.push({ id: doc.id, ...doc.data() });
  });
  return summaries;
};

export const deleteSummary = async (id) => {
  const db = getFirestore(db);
  await deleteDoc(doc(db, "summaries", id));
};

export const addSummary = async (data) => {
  try {
    const date = formatDate(new Date());
    const d = {
      summered_by: auth.currentUser.uid,
      summary: data,
      date: date,
    };
```

Figure 3.4. 33: Code snippet of summarize service

For the implementation in the image interpretation for the emotion based music player, it has both server side and client-side implementations, client-side implementations mean the mobile application and the server side implementation means the image processing process. In the mobile application implementation, it is developed using react native framework.

```
#dense 1
model.add(Dense(2*2*2*num_features))
model.add(BatchNormalization())
model.add(Activation('relu'))

#dense 2
model.add(Dense(2*2*num_features))
model.add(BatchNormalization())
model.add(Activation('relu'))

#dense 3
model.add(Dense(2*num_features))
model.add(BatchNormalization())
model.add(Activation('relu'))

#output layer
model.add(Dense(num_classes, activation='softmax'))

model.compile(loss='categorical_crossentropy',
              optimizer=Adam(lr=0.001, beta_1=0.9, beta_2=0.999, epsilon=1e-7),
              metrics=['accuracy'])

model.summary()
```

```
model = Sequential()

#1
model.add(Conv2D(2*2*num_features, kernel_size=(3, 3), input_shape=(width, height, 1), data_format='channels_last'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(Conv2D(2*2*num_features, kernel_size=(3, 3), padding='same'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2), strides=(2, 2)))

#2
model.add(Conv2D(2*num_features, kernel_size=(3, 3), padding='same'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(Conv2D(2*num_features, kernel_size=(3, 3), padding='same'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2), strides=(2, 2)))

#3
model.add(Conv2D(num_features, kernel_size=(3, 3), padding='same'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(Conv2D(num_features, kernel_size=(3, 3), padding='same'))
model.add(BatchNormalization())
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2), strides=(2, 2)))

#flatten
model.add(Flatten())
```

Figure 3.4. 34: Usage of the CNN model

The CNN model that is being used is carefully crafted to extract complex information from facial photos, enabling the recognition of subtle emotional expressions. Multiple convolutional layers with batch normalization and Rectified Linear Unit (ReLU) activation functions are the first layers in the model. The learnable filters are progressively slid across the input images by these neural layers, catching crucial details like edges and face elements. Following, max-pooling layers downscale feature maps while maintaining essential data. The output is reshaped by the flattening layer to make room for fully connected dense layers. Higher-level features are gradually abstracted from the retrieved representations by these dense layers. The output layer uses softmax activation to compute probabilities and has seven neurons that correspond to the different emotion classes. The convolutional layers serve as feature extractors throughout this process, learning to recognize important patterns and shapes, such as the curve of a grin or the furrow of brows, indicative of various emotions. Through backpropagation and Adam optimization, the model is trained to minimize a loss function while optimizing weights at a particular learning rate. After that, the model's effectiveness is assessed on validation and test datasets to make sure it has the ability to generalize and correctly identify emotions in facial photos that cannot be seen.

```
data_generator = ImageDataGenerator(
                        featurewise_center=False,
                        featurewise_std_normalization=False,
                        rotation_range=10,
                        width_shift_range=0.1,
                        height_shift_range=0.1,
                        zoom_range=.1,
                        horizontal_flip=True)


es = EarlyStopping(monitor='val_loss', patience = 10, mode = 'min', restore_best_weights=True)

history = model.fit_generator(data_generator.flow(train_X, train_Y, batch_size),
                                steps_per_epoch=len(train_X) / batch_size,
                                epochs=num_epochs,
                                verbose=2,
                                callbacks = [es],
                                validation_data=(val_X, val_Y))
```

Figure 3.4. 35: Training of the proposed model

A key element of this research is the training phase of the emotion detection model, which is distinguished by a purposeful effort to increase both the model's robustness and its capacity for successful generalization. The training set, which consists of 28,709 images, is the devoted subset of the FER-2013 dataset on which the model is thoroughly trained. A data augmentation approach is thoroughly implemented to support the model's resilience and guarantee its adaptability to various facial expressions. To provide variety to the training data, the ImageDataGenerator, a flexible tool, is used. This augmentation method expands the dataset's breadth and exposes the model to a wider range of facial emotions and changes by performing random rotations, width and height shifts, zooming, and horizontal flipping.

An early halting mechanism is intentionally used to prevent overfitting, a serious risk in DL. Throughout training, EarlyStopping supervises the model's progress by continuously keeping an eye on its performance on a different validation dataset. The validation loss is closely monitored, and if no improvement is seen after a predetermined number of training epochs, which is 10 in this case, the training process is politely terminated. By avoiding overfitting to the training data, this keeps the model's capacity to generalize to novel, unseen face expressions intact. This strategy also guarantees the model performs at its best by returning it to its ideal state, providing a strong answer for precise emotion recognition. Essentially, the combination of early stopping and data augmentation creates a model that is capable of distinguishing complex facial features while reducing the risk of overfitting, ultimately acting as a strong part of our emotion-driven music recommendation system. The journey in our user-centric system starts with users uploading emotional images via the 'uploadEmotionImage' feature. The URI, filename, and type of the picture are parameters for this function, which is managed on the front end. Giving each image a distinct URL, it smoothly delivers this image data to Firebase Cloud Storage for safe storage and retrieval. This URL is subsequently sent to the backend server, when the 'predictEmotion' function assumes center stage. A post request is orchestrated to the server's '/predict_emotion' endpoint by the 'predictEmotion' function, which is enabled by Axios. The emotion detecting process is started at this crucial stage. Behind the scenes, a pre-trained CNN model carefully examines the facial image and accurately identifies the prevalent emotion. The front end receives an immediate JSON response that contains the emotion that was identified.

```
export const fetchAudio = async () => {
  let audios = [];
  const emotion = await getFromStorage("CURRENT_EMOTION");
  console.log(`current emotion is ${emotion}`);
  const age = await getFromStorage("age");
  const ageRange = ageRangeGetter(age);

  const q = query(
    collection(db, "audio"),
    where("category", "==", emotion),
    where("ageRange", "==", ageRange)
  );
  await getDocs(q)
    .then((snapshot) => {
      snapshot.docs.map((doc) => {
        const track = new SongModel(
          doc.data()["url"],
          doc.data()["artist"],
          doc.data()["category"],
          doc.data()["ageRange"]
        );
        audios.push(track);
      });
    })
    .catch((err) => {
      console.log(`Error in get auidos ${err}`);
      return [];
    });
  return audios;
};
```

Figure 3.4. 36: Getting the person age and the predicted emotion

Following the identification and localization of the user's current feeling, our system sets out on a harmonic musical journey to enhance the emotional experience. This procedure is expertly and carefully orchestrated by the 'fetchAudio' function, which takes center stage. In order to provide a customized musical experience, it begins by obtaining the user's current feeling. The user's age is also considered, which is an important consideration. A selection of music that is age-appropriate is made possible by using age information to identify the best age range. The function creates a focused query to the music database using these inputs. It searches through the collection of audio tracks using Firebase's Firestore to find ones that fit the age range and sentiment that have been identified. The outcome is a carefully curated collection of audio tracks, each one carefully chosen to relate to the user's emotional state and age range. These songs capture a wide variety of moods and genres and are ready to take the listener on a relaxing audio journey. The 'fetchAudio' function essentially acts as a link between emotion recognition and music selection. The user's emotional context is flawlessly matched with every musical note and rhythm, increasing the emotional experience and producing a completely immersive and unique music selection. To keep the user engaged with the application a slideshow will be presented with the music screen as well.

For the implementation of face recognition, it also has both server-side and client-side implementations, client-side implementations mean the mobile application, and the server-side implementation means the face recognition process. The mobile application implementation is developed using the React Native framework.

```python

@app.get("/api")
async def caregiver_data(inputfname: str, personname: str, token: str):
    key = "RRshJy4beYdlNbu"

    if token == key:
        logger.info("INFO: Program is Running...")

        s3 = boto3.client(
            "s3",
            aws_access_key_id="AKIAXDPKO46TVVL25E4L",
            aws_secret_access_key="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",
        )

```

Figure 3.4. 37: Access the AWS S3 bucket.

Boto3 is the AWS Software Development Kit (SDK) for python. It allows developers to interact with various AWS services using python code. It provides an easy way to automate tasks and build applications that leverage AWS resources, all through python programming. Figure 3.4. shown the code that accesses the AWS S3 bucket by providing access key Id and the secret key.

```
s3bucketname = "relationphotos"
filenameinput = inputfname
s3checkdir = "Check"
donwload_folder = "/tmp"

logger.info("INFO: Input file:" + filenameinput)

prefix1 = f"{s3checkdir}/{filenameinput}"
checkfile = f"{donwload_folder}/{filenameinput}"

s3.download_file(s3bucketname, prefix1, checkfile)

if os.path.exists(checkfile):
    relations_folder = "/tmp/relations"

    if not os.path.exists(relations_folder):
        os.makedirs(relations_folder)

    s3relationsdir = "Relations"
    s3personanem = personname
    prefix2 = f"{s3relationsdir}/{s3personanem}"

    logger.info("INFO: Input person:" + s3personanem)

    result = []

    response = s3.list_objects_v2(Bucket=s3bucketname, Prefix=prefix2)
```

Figure 3.4. 38: Code snippet of Images storing in S3 bucket.

The provided code snippet (Figure 3.5) is a Python script that interacts with an AWS S3 bucket. It begins by initializing several variables, including the S3 bucket name (`s3bucketname`), an input file name (`filenameinput`), a directory prefix within the S3 bucket (`s3checkdir`), and a local download folder path (`donwload_folder`). A logging message is generated to record the input file name. The code then constructs S3 object prefixes and downloads a file from the S3 bucket to a local file path, checking for its existence. It proceeds to create a local directory (`relations folder`) if it doesn't already exist. Another S3 object prefix (`prefix2`) is formed, likely representing a directory within the S3 bucket associated with a specific person's name. The script logs this person's name and proceeds to list objects in the S3 bucket under this prefix. Overall, the code appears to be part of a larger application for managing files and data in an S3 bucket, with additional functionality beyond this snippet.

```
parsed_url = urlparse(urlforrelation)
path = parsed_url.path
directories = path.split("/")

filename = os.path.basename(path)
relation_name = directories[-3]
person_name = directories[-2]
relation_person = directories[-4]

relationfile = f"{relations_folder}/{filename}"

s3.download_file(s3bucketname, urlforrelation, relationfile)

known_image = face_recognition.load_image_file(checkfile)
unknown_image = face_recognition.load_image_file(relationfile)

biden_encoding = face_recognition.face_encodings(known_image)[0]
unknown_encoding = face_recognition.face_encodings(
    unknown_image
)[0]

relcheckresults = face_recognition.compare_faces(
    [biden_encoding], unknown_encoding
)
```

Figure 3.4. 39: Face detection and face encoding

Above code snippet (Figure 3.6) about the face detection and face encoding. The face detection algorithm looks through the image and finds areas where faces are probably to be present. Once faces are detected, the library extracts facial features from the detected faces. It uses a deep neural network to generate a numerical representation, called face encoding or face embedding, for each face. This encoding captures unique characteristics and patterns of the face. To perform face recognition, the system compares the face encodings of the detected faces with the encodings of known faces stored in a S3 bucket.

3.4.2. Testing

The testing stage of the development lifecycle of any mobile application is crucial. It entails a methodical and thorough assessment of the app's performance, security, usability, and functionality on a range of mobile platforms and devices. Professional testers and quality assurance teams carefully examine the functionality and user interface of the app during this process to find and fix any bugs, flaws, or inconsistencies. Through testing for compatibility, the software is ensured to work flawlessly across a range of operating systems, screen sizes, and device settings, ensuring a great user experience for a large audience. While security testing protects sensitive user data and the integrity of the app overall, performance testing evaluates the app's responsiveness and speed. Real users participate in user acceptability testing, providing comments on the usability and general happiness of the app.

Some of the test cases used to test the product are included below, along with screenshots.

Table 3.4.2. 1: Test whether live location is correctly tracking and refreshing.

Test Case ID	01
Test Case	The live location of the patient should be displayed correctly and should be updated frequently.
Test Scenario	Verify that the live location tracking updates every 10 seconds as expected.
Pre-condition	- Mobile application is running. - Tracking device is active.
Input	Patient’s mobile device is in motion.
Expected output	- The live location should be updated every 10 seconds. - Caregivers should see the updated location on the map.
Actual output	- The live location is updating every 10 seconds. - Caregivers can see the updated location on the map.
Test status	Passed

Table 3.4.2. 2: Whether geo-fencing can be applied correctly.

Test Case ID	02
Test Case	The Geo-fencing feature should work correctly and must create safe zones/boundaries.
Test Scenario	Verify that caregivers can define safe zones within the map using geo-fencing.
Pre-condition	- Mobile application is running. - Caregiver is logged in.
Input	The caregiver selects an area of the map to set as the safe zone.
Expected output	- The safe zone should be successfully defined. - It should appear on the map. - No alerts should be triggered at this point.
Actual output	- The safe zone is successfully defined. - It appears on the map. - Alerts are not triggered at this point.
Test status	Passed

Table 3.4.2. 3: Whether alerts are correctly triggered to the caregivers.

Test Case ID	03
Test Case	When a patient crosses the defined safe zones, alerts need to be triggered and sent to caregivers' mobile phone as text messages.
Test Scenario	Verify that alerts are triggered when the patient crosses a defined safe zone.
Pre-condition	- Mobile application is running. - Geo-fencing is set up with at least one safe zone. - The patient's location is within a safe zone.
Input	Patient crosses the boundary of a defined safe zone.
Expected output	- Alerts should be triggered. - The system should send messages to the caregiver's mobile phone.
Actual output	- Alerts are triggering. - The system sends messages to the caregiver's mobile phone.
Test status	Passed

Table 3.4.2. 4: Whether location predictor works fine in emergency situations.

Test Case ID	04
Test Case	In emergency situations such as device malfunctions, location predictor must show the correct location.
Test Scenario	Verify that the machine learning model predicts the patient's location in case of an emergency.
Pre-condition	- Mobile application is running. - The machine learning model is integrated and active in the application.
Input	Patient's behavior or location indicates an emergency (e.g.- Device malfunction)
Expected output	The machine learning model should predict the patient's likely location, and this prediction should be shared with the caregiver along with an alert.
Actual output	Correct location has been predicted 96% of the occasions.
Test status	Passed

Table 3.4.2. 5: Whether application is working under heavy network traffic.

Test Case ID	05
Test Case	When application is used by many users at the same time, it should work without any obstacles or delays.
Test Scenario	Verify that the application performs well under heavy load when multiple caregivers tracking multiple patients simultaneously.
Pre-condition	Multiple caregivers are using the application simultaneously, tracking multiple patients.
Input	Continuous location updates and geo-fencing activities for multiple patients and caregivers.
Expected output	- The application should remain responsive. - Location updates should not significantly slow or lag.
Actual output	- The application remains responsive. - Location updates are not slow down or lag on 95% of the occasions.
Test status	Passed

Table 3.4.2. 6: Whether patient’s historical records can be retrieved.

Test Case ID	06
Test Case	Patient’s historical data can be retrieved without any problems.
Test Scenario	Verify that caregivers can access and view historical location records of the patient.
Pre-condition	- Mobile application is running. - The patient's historical location data is available.
Input	Caregiver selects a date and time range to retrieve historical location data.
Expected output	The application should display a history of the patient's movements, including where and when they traveled during the specified time range.
Actual output	The application displays the history of the patient’s movement and all the relevant details successfully.
Test status	Passed

Table 3.4.2. 7: Whether patient's historical data is exported.

Test Case ID	07
Test Case	All the data should be stored and exported in the patient’s history as documentation.
Test Scenario	Verify that caregivers can export historical location records for documentation or analysis.
Pre-condition	- Mobile application is running. - Historical location data is available.
Input	Caregiver selects a date and time range to export historical location data.
Expected output	All the records should be exported successfully.
Actual output	All the records export successfully.
Test status	Passed

Table 3.4.2. 8: Whether data privacy and security can be proven.

Test Case ID	08
Test Case	All the data should be protected with privacy and security terms.
Test Scenario	Verify that patient location data is securely stored and accessed only by authorized caregivers.
Pre-condition	- Mobile application is running. - Patient data is stored securely.
Input	Attempted unauthorized access to patient location records.
Expected output	- Unauthorized access should be denied. - Caregivers should only be able to access patient location data after proper authentication and authorization.
Actual output	- Unauthorized access is denied. - Caregivers can only be able to access patient location data after proper authentication and authorization.
Test status	Passed

Table 3.4.2. 9: Test cases for audio diary

Test Case #	**Test case**	**Result**
001	Asking permissions to access microphone	Pass
002	All the buttons and widgets are visible	Pass
003	Navigate for pages through buttons	Pass
004	Voice recording successfully saved	Pass
005	Text conversion happened successfully	Pass
006	Text summarization happened successfully	Pass
007	Accessing daily records via the calendar	Pass
008	Care giver accessible for summarized texts	Pass
009	Saving the audio file	Pass
010	Saving the converted text file	Pass
011	Saving the summarized text file	Pass

Table 3.4.2. 10: Test cases for music player

Test Case #	**Test case**	**Result**
001	Camera opens from the open camera button	Pass
002	All the buttons and widgets are visible	Pass
003	Navigate for pages through buttons	Pass
004	Vibration works when touch the buttons	Pass
005	Image successfully captured after opening the camera	Pass
006	Image successfully uploaded for the algorithms	Pass
007	Detect the emotion	Pass
008	Detected emotion is displayed in the screen	Pass
009	Listen to music button is clicked	Pass
010	Appropriate Music is generated to the user	Pass
011	Slideshow is working properly	Pass

Table 3.4.2. 11: Test cases for face recognition page.

Test Case #	**Test case**	**Result**
001	Camera opens from the open camera button	Pass
002	All the buttons and widgets are visible	Pass
003	Navigate for pages through buttons	Pass
004	Image successfully captured after opening the camera	Pass
006	After capturing the image navigate to the next page	Pass
007	After press the save button give success alert	Pass
008	Load the name and relationship	Pass
009	Load the memory images	Pass

Test Case #	Test case	Result
001	Camera opens from the Add memory button	Pass
002	All the buttons and widgets are visible	Pass
003	Navigate for pages through buttons	Pass
004	Access the phone gallery when press the pick image from gallery button.	Pass
005	Image successfully captured after opening the camera	Pass
006	After capturing the image navigate to the next page	Pass
007	Navigate to the camera page after press the re-take button	Pass
008	Load the text fields for type name and relationship.	Pass
009	When selecting the 'pick image ' navigate to the phone gallery.	Pass
010	User able to choose multiple images	Pass
011	After press the save button give success alert	Pass
012	Proper page alignment	Pass
013	Display words with correct spellings	Pass
010	After press the sound button gives the voice output	Pass
011	Proper page alignment	Pass
012	Proper words with correct spellings	Pass

Table 3.4.2. 12: Test cases for add memory page

Above tables show the test cases done. Also, this application was tested by using two end users and below table shows the results of it. For that we contacted two people with moderate dementia and a one who are capable of speaking English. Those people are respectively named in the table as User 2 and User 1.

Table 3.4.2. 13: Test cases for end users: audio diary

Test Case #	Test case	User 1	User 2
001	Open the mobile application without any error	Opened the application without any issue	Opened the application without any issue
002	Recording started after touching record button	Able to record the voice.	Able to record the voice.
003	Navigate for pages through buttons	Navigated through all the pages	Navigated through all the pages
004	Text conversion started after touching convert to text button	Able to view the text	Able to view the text
005	Text summarization happened	Text summarized to a small paragraph	Text summarized to a small paragraph

Table 3.4.2. 14: Test cases for end users: music player

Test Case #	**Test case**	**User 1**	**User 2**
001	Open the application without any error	Opened the application without any issue	Opened the application without any issue
002	Camera opens from the Music icon in the home page.	Able to open the camera	Able to open the camera
003	Navigate for pages through buttons	Navigated through all the pages	Navigated through all the pages
004	Vibration works when navigating through buttons	Navigated through the pages with the help of vibration	Navigated through all the pages
005	Able to capture the image successfully	Captured the image without any issue	Captured the image without any issue

Table 3.4.2. 15: Test cases done by end users : face recognition

Test Case #	Test case	User 1	User 2
001	Open the mobile application without any error	Opened the application without any issue	Opened the application without any issue
002	Camera opens from the open camera button	Able to open the camera with the guidance of voice assistant	Able to open the camera from the camera button
003	Navigate for pages through buttons	Navigated through all the pages	Navigated through all the pages
004	Able to capture the photo successfully	Captured the image without any issue	Captured the image without any issue
005	Display the data of the captured photo of the person	Display without any issue.	Display without any issue.
006	Provide voice output of the displayed data	Provide without any issue.	Provide without any issue.

Finally, to complete the testing process we tested out applications with different OS versions with different kind of android devices. The test cases for that are shown below in the table.

Table 3.4.2. 16: Test cases for different devices

Test Case #	Device	OS	Version issues	Issues with the interfaces
001	Xiaomi X3Pro Poco phone	Android 13	No issues	No issues
002	Redmi 9	Android 11	No issues	No issues
003	Samsung galaxy grand prime	Android 5	No issues	No issues

4. RESULTS AND DISCUSSION

4.1. Results

4.1.1. Results for location tracker

For location prediction functionality, various algorithms have been used. In the early stages of the implementation, location name-based predictions have happened and for that algorithms such as Logistic Regression, K-Nearest Neighbor and Decision Tree have been considered and tested. In the below figure 4.1.1 it shows the used algorithms and the accuracies that have been gained for each ML model.

```
# calling method - model_executor_and_acuracy
for model in models:
    model_executor_and_acuracy(model)
```

```
<<<<====== LogisticRegression() ====>>>>
Accuracy: 0.48119325551232167
<<<<====== DecisionTreeClassifier() ====>>>>
Accuracy: 0.9416342412451362
<<<<====== KNeighborsClassifier(n_neighbors=2) ====>>>>
Accuracy: 0.7198443579766537
```

Figure 4.1. 1: Various Algorithms that have been used and accuracies of them.

As demonstrated above, accuracies for Logistic Regression, Decision Tree and K-Nearest Neighbor algorithms are 48.12%, 94.16% and 71.98% respectively.

Then after acquiring the location tracking device, it was evident that Decision tree algorithm is not the most suitable when it comes to location predictions using latitude and longitude. So, in order to fulfil that, LSTM and Random Forest Regressor algorithms have been used. Although both are equal considering the accuracies, the result generating time and with LSTM being a RNN, it takes a lot of computational power, it was proven that Random Forest algorithm is the most suitable option. To determine the accuracy, MAE and MSE have been considered.

The results are shown in figure 4.1.2 below.

```
# Predictions on the test set
y_pred_lat = rf_model_lat.predict(X_test_lat)
y_pred_long = rf_model_long.predict(X_test_long)

# Calculate Mean Absolute Error (MAE)
mae_lat = mean_absolute_error(y_test_lat, y_pred_lat)
mae_long = mean_absolute_error(y_test_long, y_pred_long)

# Calculate Mean Squared Error (MSE)
mse_lat = mean_squared_error(y_test_lat, y_pred_lat)
mse_long = mean_squared_error(y_test_long, y_pred_long)

# Print Mean Abssolute Errorrs and Mean Squared Errors for latitude and longitude
print("Mean Absolute Error for Latitude:", mae_lat)
print("Mean Absolute Error for Longitude:", mae_long)
print("\nMean Squared Error for Latitude:", mse_lat)
print("Mean Squared Error for Longitude:", mse_long)
```

```
Mean Absolute Error for Latitude: 0.0027349905006102955
Mean Absolute Error for Longitude: 0.0022434401084643635

Mean Squared Error for Latitude: 0.0001891661636282364
Mean Squared Error for Longitude: 0.0002546713325623277
```

Figure 4.1. 2: MAE and MSE values for Random Forest Algorithm

As demonstrated above, MAE and MSE have been calculated separately for latitude and longitude. MAEs for latitude and longitude are 0.27% and 0.22% respectively. Then MSEs for latitude and longitude are 0.019% and 0.025%. Since the deviations are so small it is proven that accuracy of this model is high as well.

As demonstrated above, MAE and MSE have been calculated separately for latitude and longitude. MAEs for latitude and longitude are 0.27% and 0.22% respectively. Then MSEs for latitude and longitude are 0.019% and 0.025%. Since the deviations are so small it is proven that accuracy of this model is high as well.

When considering the map related functionalities, live location tracking mechanism is working correctly. Map indicator shows as a car logo since the tracker is a portable device which was made and meant to track vehicles. Also, there is a security restriction from the goggle regarding indicator changes, but we are trying to make it more user friendly and less confusing.

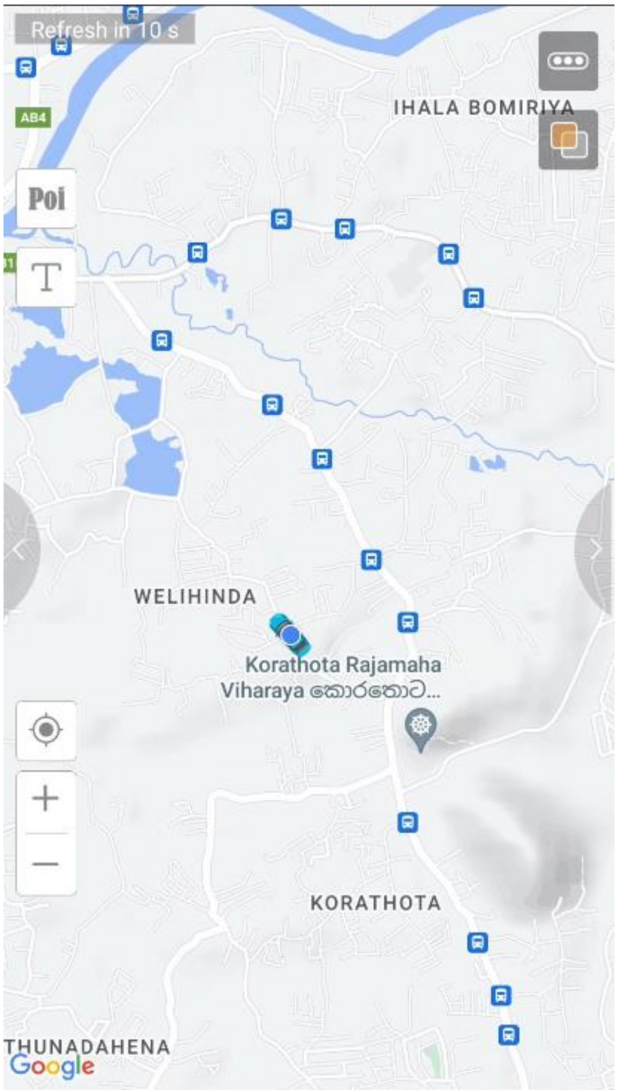


Figure 4.1. 3: When the patient is nor moving.

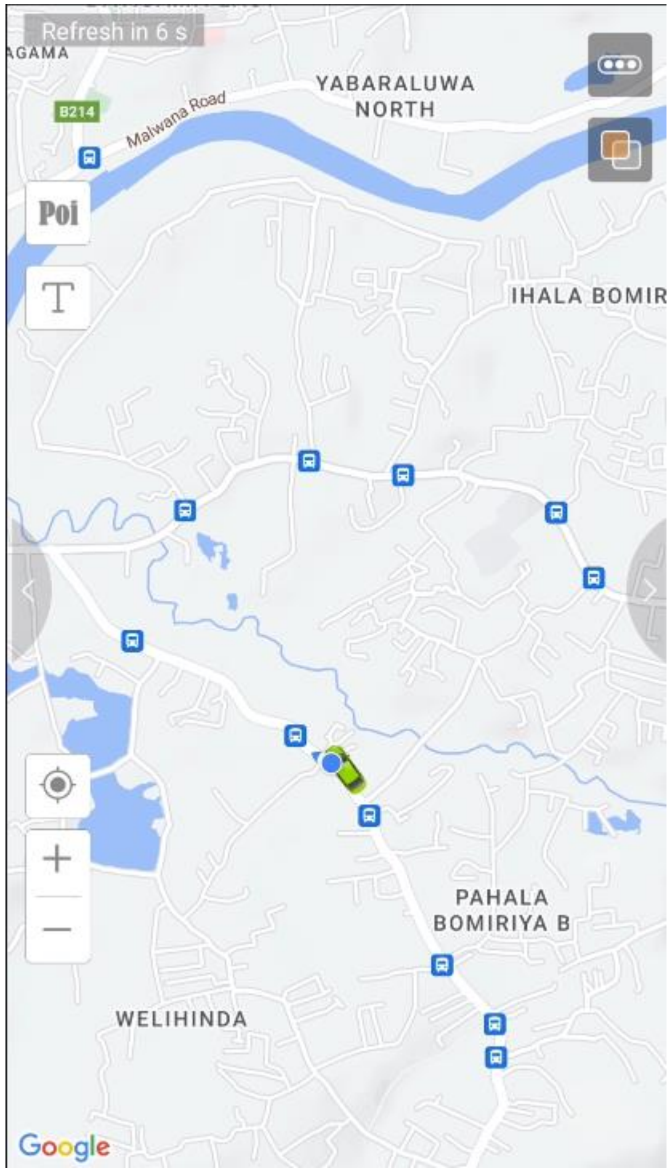


Figure 4.1. 4: When the patient is moving.

As shown in the above figures, the live location of the patient with the status as whether the person is moving or not. When moving, the indicator displays as light green. Then when the patient is not moving, the indicator displays in blue. This provides user friendly and easily recognizable details to the people who are watching.

Then to define safe zones/boundaries, geo fencing features have been used. The following figures emphasize that.

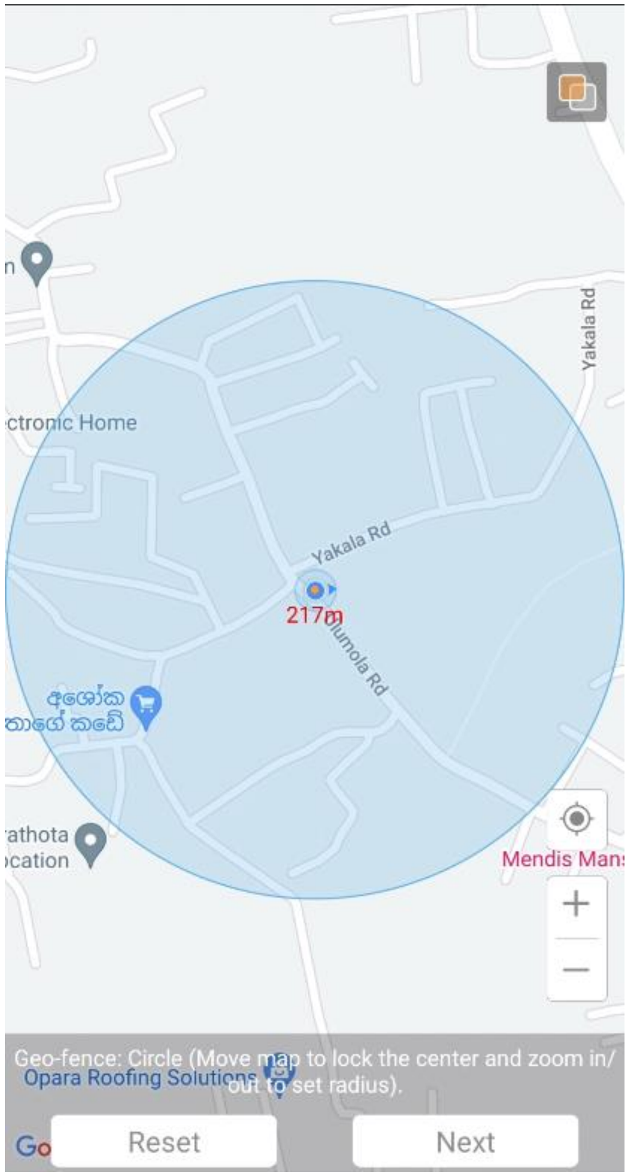


Figure 4.1. 5: Defining safe zones as a circle.

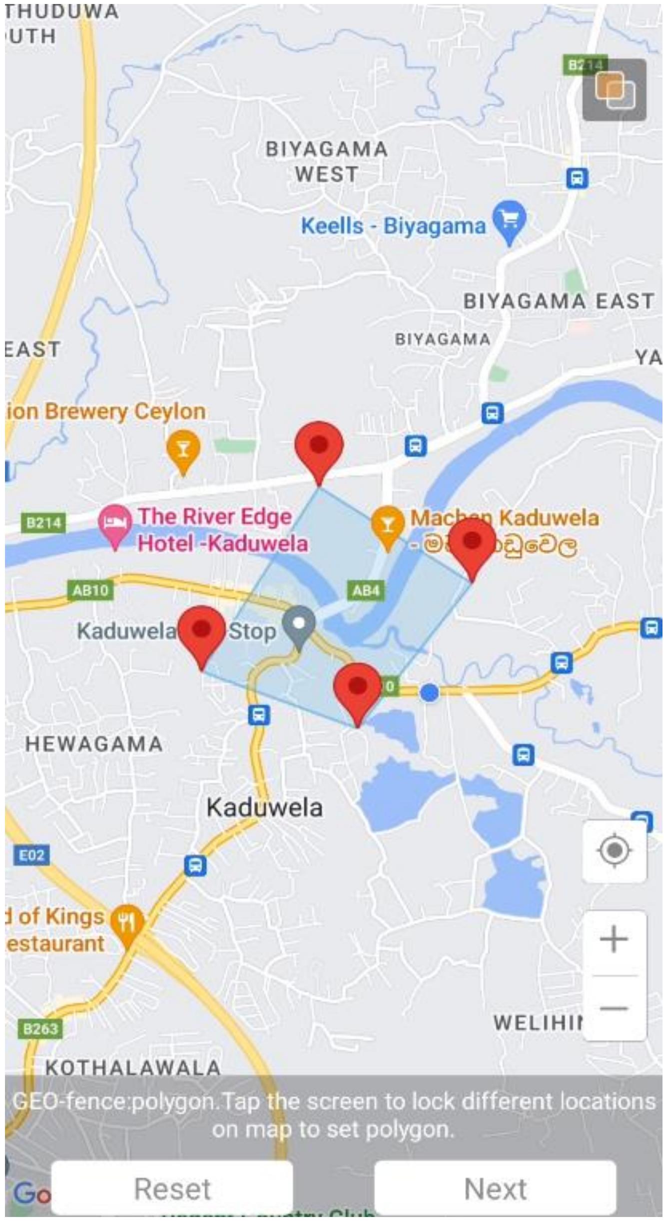


Figure 4.1. 6: Defining safe zones according to caregivers need.

Then Above figures showcases the two modes of defining safe zones. Figure 4.1.5 shows the default functionality where caregivers can define safe zones by centering on a particular location and with a equal radius around it. Figure 4.1.6 shows that caregivers can customize the safe zones according to their needs by marking minimum of 3 and maximum of 4 locations in the map.

The facility to view patients' historical records has been provided with this whole system and it can be demonstrated from the figures below.

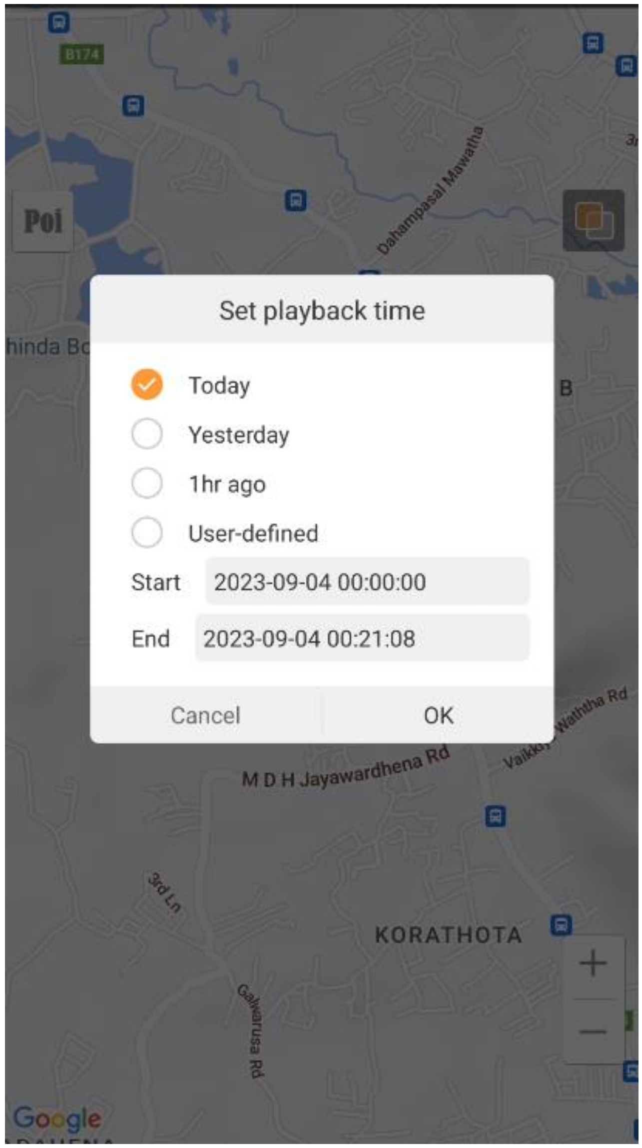


Figure 4.1. 7: Giving inputs to view patients past records.

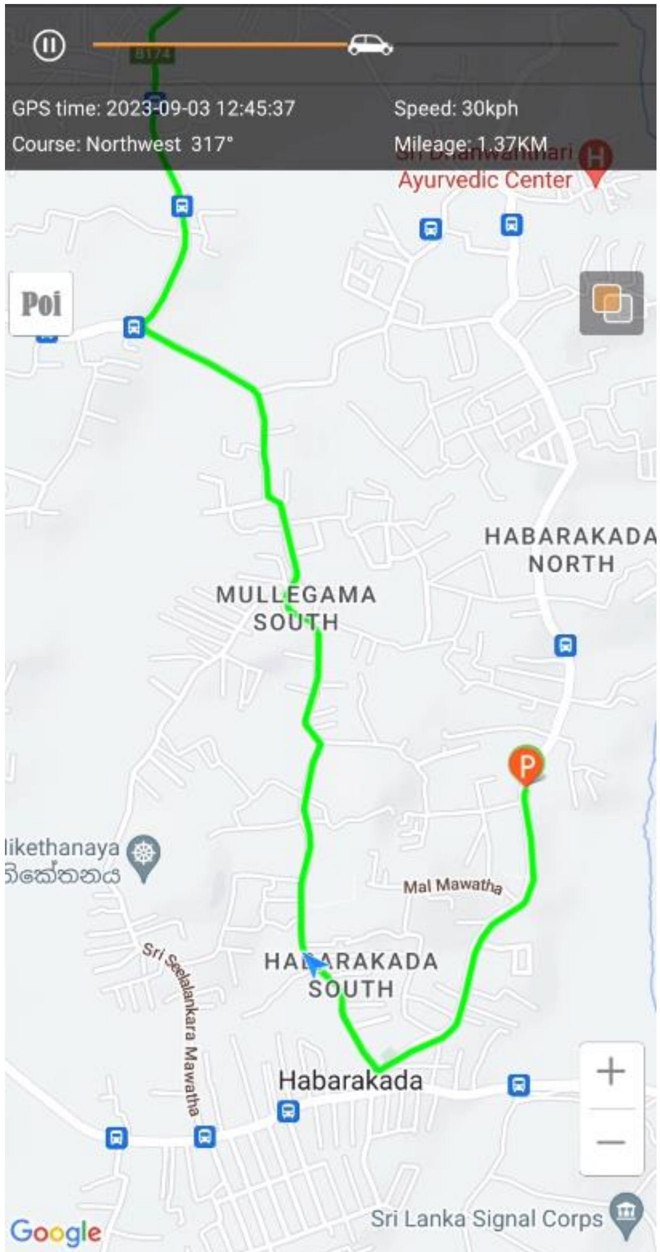


Figure 4.1. 8: Viewing playbacks of patient's movements.

Figure 4.1.7 shows how caregivers can provide inputs and search past records to their needs and figure 4.1.8 displays a playback of patient's movements.

4.1.2. Results for audio diary

A significant step forward in improving the quality of life for people with moderate dementia has been made possible by the successful voice recognition and voice-to-text conversion testing results within a mobile application. The program has successfully captured the ideas and recollections of users who may struggle with cognitive impairments through careful testing of its capacity to faithfully translate spoken words into text.

This accomplishment creates new opportunities for dementia patients to easily record their thoughts, feelings, and observations from day to day, encouraging a sense of independence and self-expression. As a result of the app's effectiveness with speech recognition, users can engage with it naturally, which lessens annoyance and makes it more approachable for people with different levels of technological expertise. Overall, these favorable outcomes have the potential to improve not just the usability of the mobile app but also the wellbeing and cognitive ability of dementia patients.

The positive results achieved through fine-tuning the BART model for text summarization have been nothing short of transformative for natural language processing tasks. By fine-tuning diverse datasets and domain-specific corpora, BART has exhibited exceptional proficiency in abstractive summarization. Its ability to generate coherent, concise, and contextually relevant summaries from lengthy texts has made it an indispensable tool across various applications. The model excels in distilling information from complex documents, making it invaluable in news summarization, academic research, and content curation. Furthermore, BART's adaptability to different languages and domains enhances its versatility, making it an ideal choice for multilingual summarization tasks. These positive outcomes have not only streamlined content summarization processes but have also significantly improved the accessibility of information, making it more digestible and accessible to a wider audience. In essence, fine-tuning the BART model for text summarization has ushered in a new era of efficient and effective information extraction, benefiting industries, researchers, and consumers alike.

BART can distill lengthy diary entries into concise and coherent summaries. This is particularly useful when people want to revisit past entries quickly or when caregivers or healthcare professionals need a quick overview of a patient's daily experiences. For individuals with cognitive impairments, like dementia patients, BART's summarization can serve as a memory aid. It condenses complex thoughts and emotions from diary entries, helping users recall significant events and emotions they might otherwise struggle to remember. Manually reviewing or transcribing lengthy diary notes can be time-consuming. BART automates the summarization process, saving both time and effort for users and caregivers. BART's summarization can make diary entries more accessible to a wider audience, including those who may find it challenging to read lengthy text. This is particularly important in healthcare settings or when sharing diary notes with family members and caregivers.

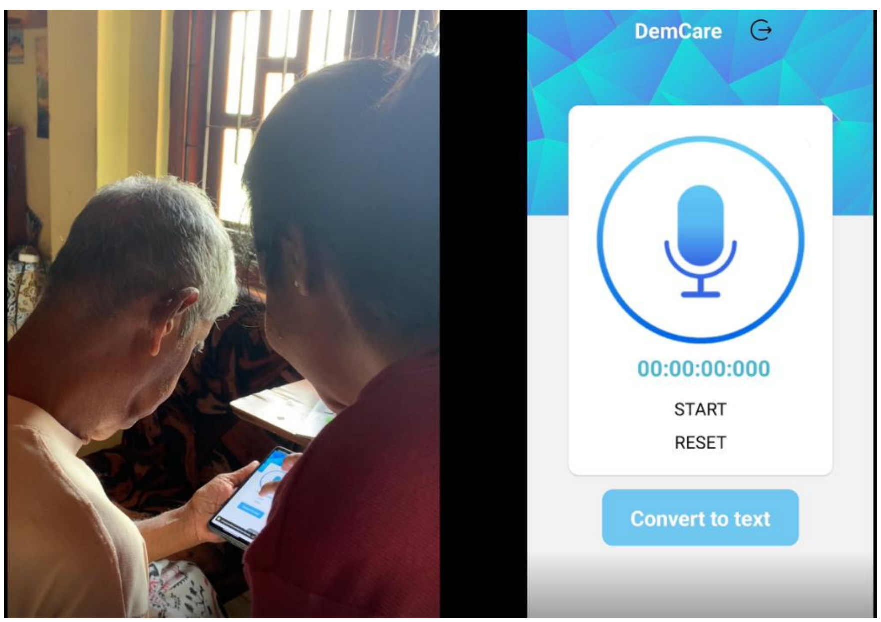


Figure 4.1. 9: Testing the diary component with a patient

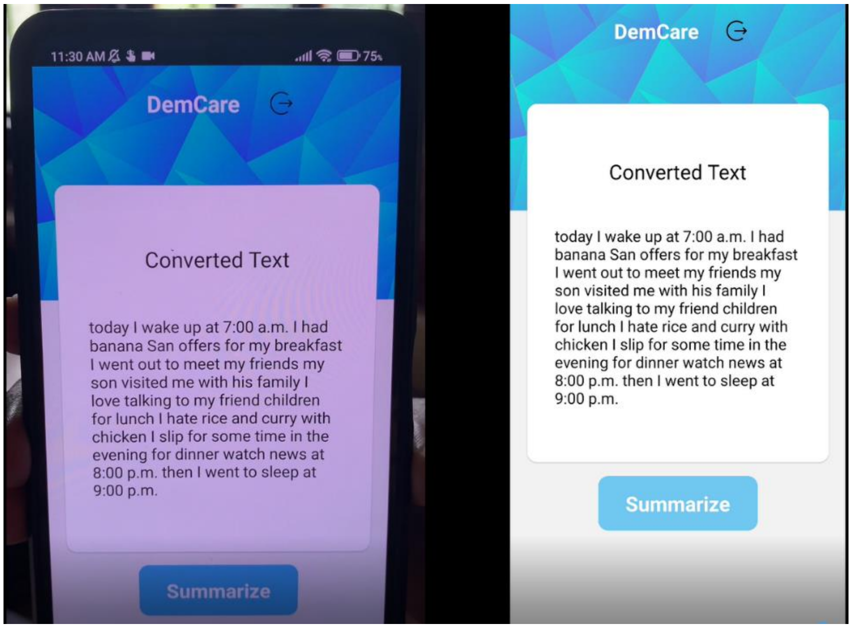


Figure 4.1. 10: Testing the speech to text conversion

4.1.3. Results for music player

The system for captioning images provides the person's present emotional state for nearly every image. As the features of the detected image is extracted with this CNN model the accuracy of the generating emotions is also high as shown in figure 4.1.1 which is a confusion matrix generated to the model implemented.

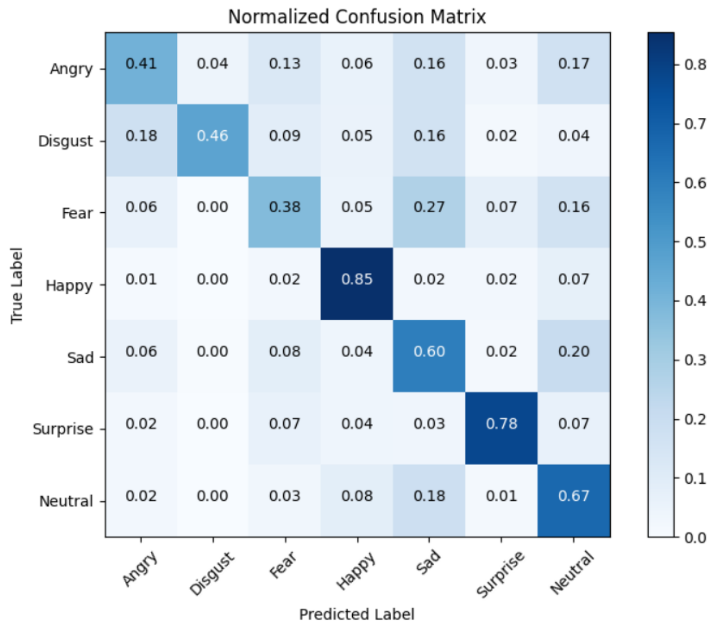


Figure 4.1. 11: Accuracy of the generated attributes

As shown above, the accuracy for the attributes happy, sad, surprise, neutral, fear, disgust and angry are respectively 88%,60%,78%,67%,38%,46%,41%.

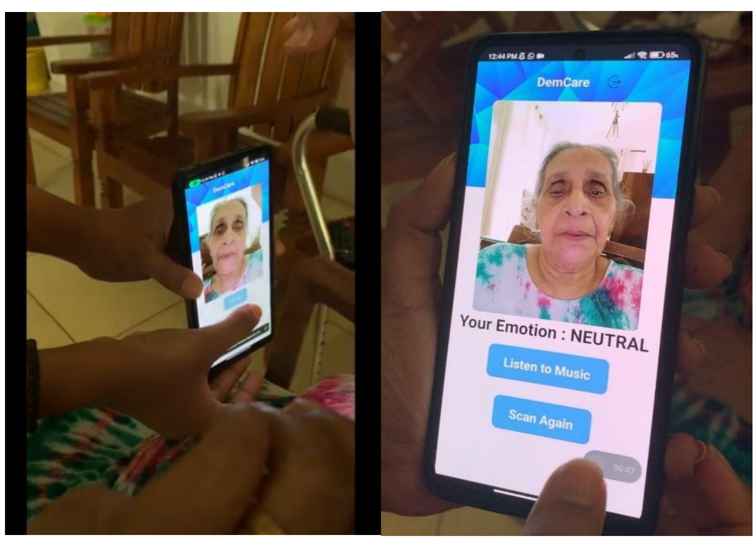


Figure 4.1. 12: Sample image tested with a moderate dementia patient and the detected emotion

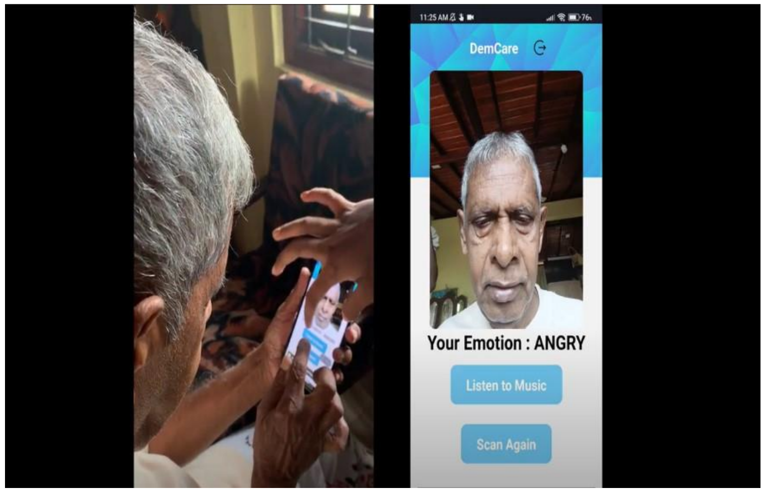


Figure 4.1. 13: Sample image of a mild dementia individual and the result

Figure 4.1.2 and Figure 4.1.3 display two outcomes that were gathered from individuals. As you can see, the projected emotions closely match the patient's actual emotional state at the moment. Thus, it is evident that the mobile application's implementation provides highly accurate forecasts.

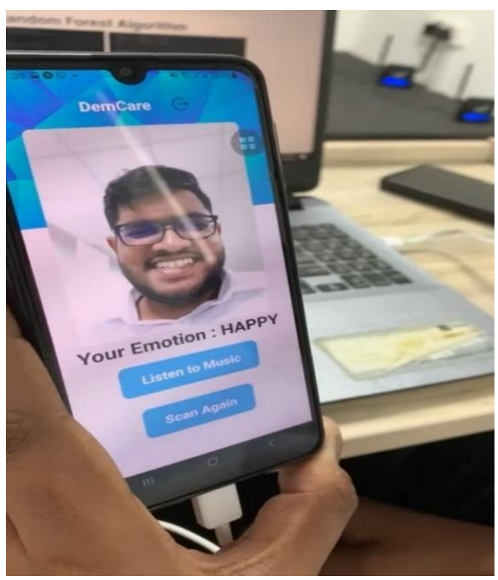


Figure 4.1. 14: Sample image tested with a team member

4.1.4. Results for face recognition

The face recognition system works using a live training mechanism. Therefore, there no limit for the faces that can be identified. It displays name and the relationship for captured photo that are useful enough for dementia patients to identify person. In figure 4.1.1 shows the postman request for the created API.

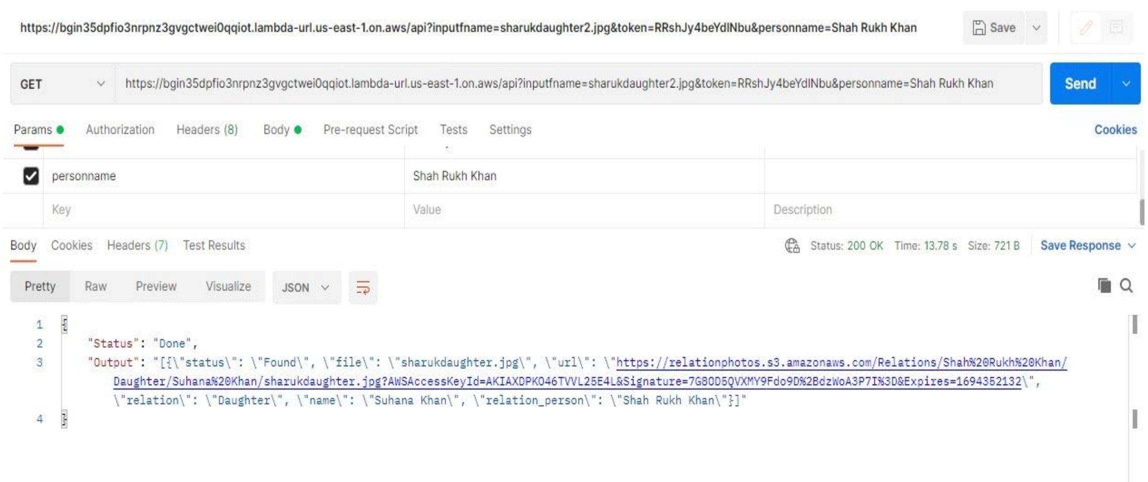


Figure 4.1. 15: Postman GET request.

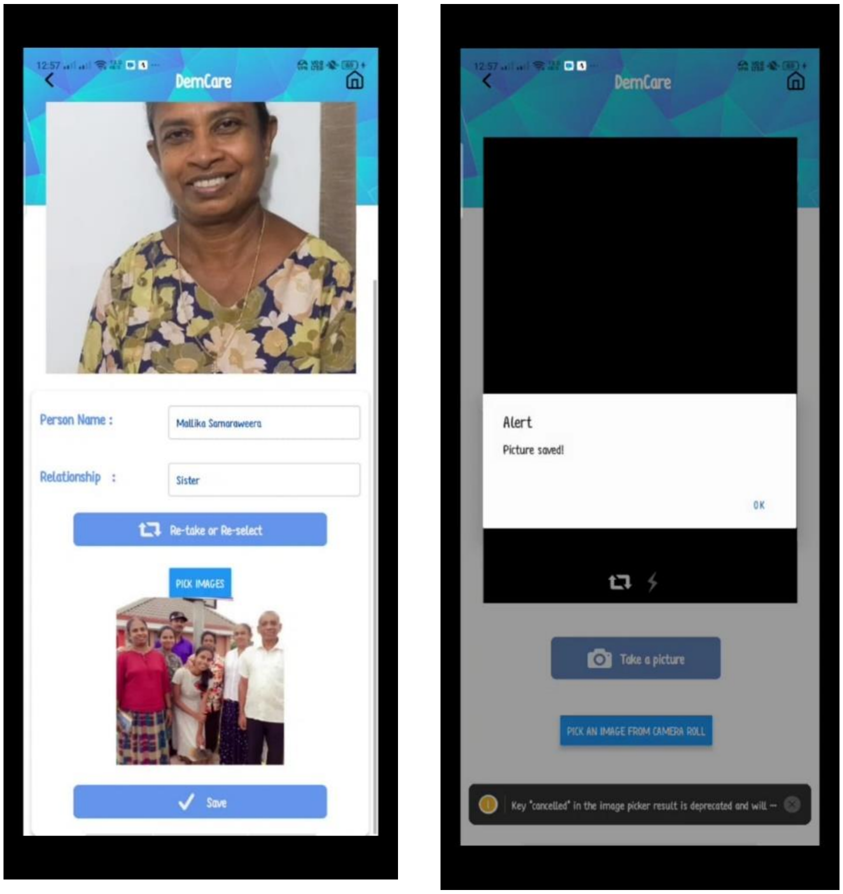


Figure 4.1. 16: Add the people to the system (Caregiver Part).

After pressing the "save" button it displays the success alert shown in figure 4.2.

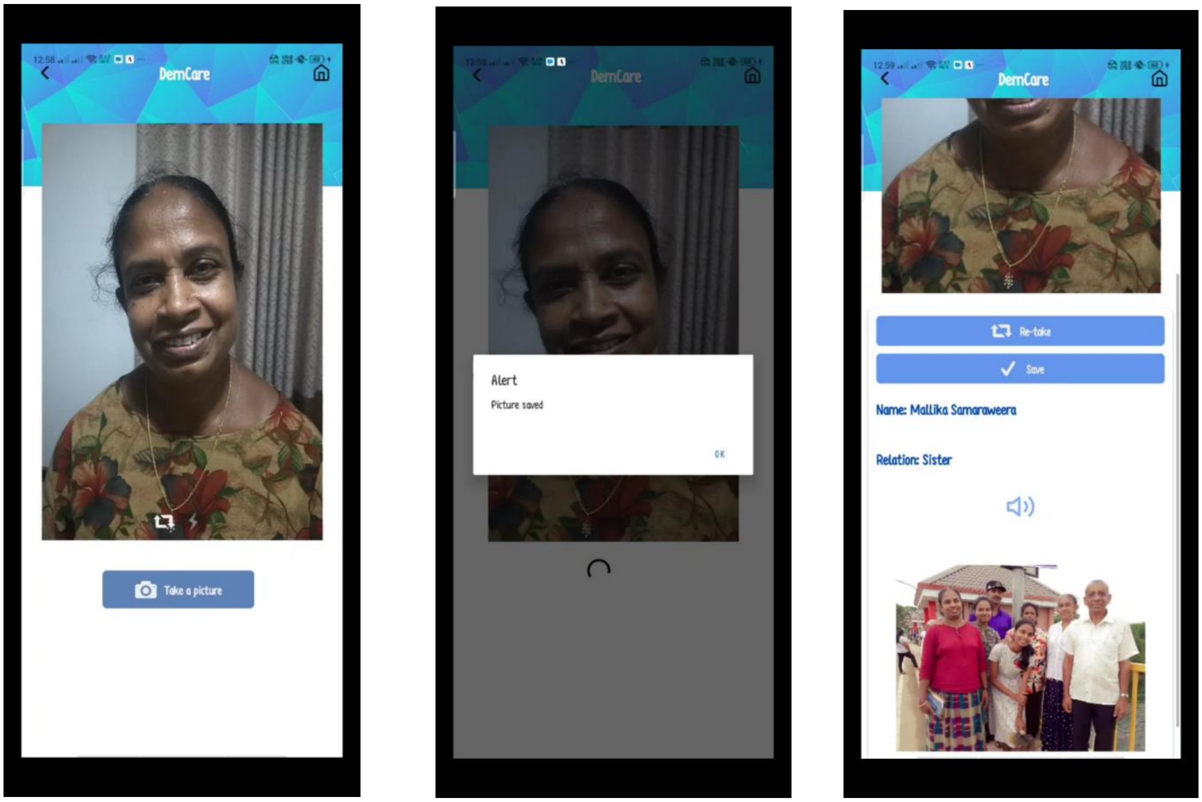


Figure 4.1. 17: Identified the faces.

Figure 4.3 shows results that are displayed in the implemented face recognition component. As you can see, the name and the relationship are displayed correctly. So, it is clearly shown that the implemented mobile application gives a highly accurate result and the capability of identifying faces.

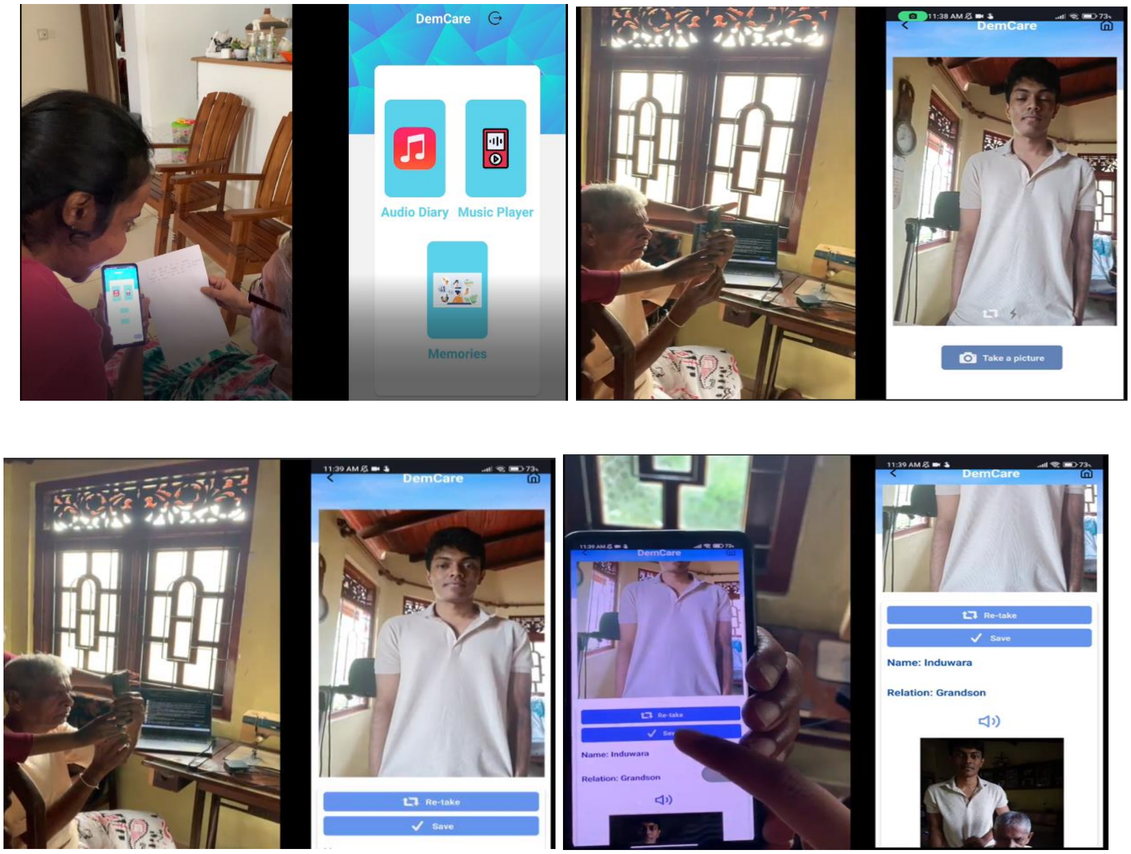


Figure 4.1. 18: Sample image tested with dementia patient.

Our team was founded a mild level male dementia patient around 75 years old. Therefore, we got the chance to test and get feedback on the implemented solution. He tested the application with his grandson. In figure 4.4 shows the snapshots that were taken on that day.

4.2. Research Findings

4.2.1. Findings for location tracker

The study's goal was to address the difficulties caused by wandering behavior in dementia patients, as well as the strain placed on caregivers. The study's findings were based on a review of the literature, which comprised several research studies and journal articles. A Google Form was also used to collect data from caregivers in order to acquire a better understanding of their experiences and needs.

The designed mobile application, built using React-Native and using Firebase as the database, provides a multifaceted solution for improving dementia patient care. The application uses a location-tracking device, the VT03D portable device, to track dementia sufferers in real time. This device, which is enabled with a mobile SIM card and linked via its EMEI number, updates the patient's live location every 10 seconds, giving caregivers ongoing awareness of the patient's surroundings.

Caregivers have the authority to construct and change safe zones for patients. When a patient wearing the tracking device crosses established safe zones, the system sends fast alerts to caregivers' mobile phones via text message. This function improves patient safety and reduces the chance of wandering behavior. The application keeps complete historical records of patient mobility, including travel routes and timestamps. Caregivers have access to these records and can even relive previous events. This feature allows for a more in-depth analysis of patient behavior and habits.

For the location prediction mechanism, the study used Decision Tree and Random Forest algorithms to achieve a remarkable 94.16% accuracy in location prediction. The prediction mechanism aids carers in estimating the patient's future location, hence improving proactive care. In addition to Decision Tree algorithm, the study explored K-Nearest Neighbor and Logistic Regression algorithms for name-based location prediction. However, as compared to Decision Trees, these options produced lower accuracies. In emergency situations, such as device malfunctions or dead batteries, the location prediction system proves invaluable by providing insights into the projected patient position. This feature ensures that major incidents are handled in a timely manner.

4.2.2. Findings for audio diary

Dementia, particularly in its moderate stages, poses significant challenges for individuals and caregivers alike. In pursuit of innovative solutions to enhance the lives of those affected, extensive research has been conducted into the development of an Audio Diary with Text Conversion and Summarization application tailored specifically for moderate dementia patients. Here are some findings gathered.

- Enhanced memory recall - One of the most remarkable findings from this research indicates that this component plays a pivotal role in enhancing memory recall among moderate dementia patients. By enabling users to effortlessly record their thoughts and experiences in spoken form, the application not only preserves their precious memories but also converts them into written text. This transformative feature empowers patients to revisit and reflect upon their past experiences, fostering a sense of continuity and self-awareness.

- Streamlined communication – this component has proven to be a valuable tool in facilitating communication between dementia patients, caregivers, and healthcare professionals. The text conversion and summarization capabilities enable users to articulate their thoughts more coherently, reducing frustration and miscommunication. Caregivers and healthcare providers, in turn, gain insights into the patient's daily experiences, allowing for more effective care planning and emotional support.

- Improved emotional wellbeing - Our research has demonstrated a significant improvement in the emotional well-being of moderate dementia patients who use this mobile app. The ability to express their feelings and thoughts in a diary format fosters emotional release and self-expression, reducing anxiety and depression often associated with dementia. The summarized text entries provide patients with a digestible overview of their experiences, helping them process and manage their emotions more effectively.

- Caregiver relief - this has also had a profound impact on caregivers. By automating the summarization of diary entries, it relieves caregivers of the time-consuming task of reviewing and transcribing lengthy notes. This not only reduces caregiver stress but also allows them to allocate more quality time to their loved ones.

4.2.3. Findings for music player

The study's findings highlight the usefulness and efficacy of the suggested emotion-driven music recommendation system. The system recognized a variety of emotions, such as happy, sadness, anger, and neutral, with respectable accuracy by using a pre-trained CNN model for emotion recognition. The model's performance was improved, and overfitting was minimized by the use of data augmentation approaches, guaranteeing that it could successfully generalize to new data. The personalized "musicService" collection showcased its skill at selecting musical pieces that connected with the emotions and age range of consumers, enhancing their mood and emotional experience. User engagement was greatly increased by the user-centric strategy, which included seamless image capture, emotion detection, and music selection. The architecture of the system, which uses

Firebase for image storage and retrieval and Firestore for music database queries, also proved to be effective and scalable. Age was taken into consideration when choosing music, ensuring that choices were made that catered to a variety of user demographics. These research findings show how the system can be used in the real world to enhance mental health, provide entertainment, and improve user experiences through emotional involvement.

4.2.4. Findings for face recognition

This research project has a primary focus on the development of a dedicated mobile application designed to assist in identifying relatives and family friends of individuals living with dementia. Notably, there is a significant gap in existing research that addresses this aspect of dementia care. While various mediums have been explored to aid dementia patients, they often encounter numerous obstacles that remain unaddressed.

The principal objective of this study is to harness the power of neural network techniques, specifically through mobile applications, to enhance the independence and overall quality of life for individuals with mild to moderate dementia. By leveraging the capabilities of neural networks, this application aims to provide valuable support and assistance to this demographic.

One noteworthy achievement of this research is the remarkable accuracy achieved by the implemented system, which surpasses an impressive 99.38%. This outstanding level of accuracy ensures that the system can reliably and consistently identify individuals' faces, marking a significant advancement in face recognition technology.

The successful implementation of this face recognition system owes much to the utilization of various Python libraries and cutting-edge deep learning techniques. Convolutional neural networks and other contemporary deep learning algorithms have played a pivotal role in driving the effectiveness of this system, demonstrating their versatility and applicability in various domains, including dementia care.

In conclusion, this research endeavor holds the potential to substantially enhance the independence and quality of life for individuals with mild to moderate dementia. By harnessing the power of neural networks and face recognition technology, this mobile application serves as a promising tool in addressing the unique challenges faced by dementia patients and their caregivers.

4.3. Discussion

This research study highlights the significance of a developed application for addressing challenges faced by dementia patients and caregivers. The application's real-time tracking and alerting system effectively manages wandering behavior, enhancing patient safety and reducing caregiver stress. It also empowers dementia patients to move within predefined boundaries, striking a balance between autonomy and safety. The high accuracy of location prediction mechanisms, particularly Decision Trees and Random Forest algorithms, adds a reliable layer of security to patient care. However, potential limitations like device dependency and patient cooperation should be acknowledged, and future research should explore additional machine learning algorithms and improve the user interface to further enhance dementia care.

One pivotal aspect of our research paper focuses on the discussion of how the Audio Diary with Text Conversion and Summarization addresses the profound challenges of communication and memory preservation in the context of moderate dementia patients. By employing the React Native Voice Library, this innovative solution empowers these individuals to express themselves with ease and clarity, despite the linguistic and cognitive difficulties often associated with dementia. The voice-to-text conversion feature becomes a bridge, allowing patients to articulate their thoughts and emotions in their own voice, preserving not just the words but also the authenticity of their experiences.

Furthermore, the integration of the BART model plays a crucial role in the memory preservation process. It offers the capability to transform spoken recollections into written text, creating a digital archive of personal narratives that can be revisited at any time. This has a profound impact on the patient's emotional well-being, fostering a sense of continuity and self-identity as they are able to recall and reflect upon their past experiences, even as memory challenges persist.

By offering an accessible and intuitive means of expression and memory preservation, this component goes beyond being a mere technological tool; it becomes a source of empowerment for moderate dementia patients. It enables them to communicate their feelings, experiences, and preferences, thereby enhancing their quality of life and enabling them to maintain a sense of independence. The technology serves as a testament to the potential of merging cutting-edge solutions like the React Native Voice Library and the BART model with compassionate care, ultimately improving the lives of those navigating the complexities of dementia.

Throughout the research's development and evaluation phases, a number of important factors were found. In the past, some research on the topic was conducted to gain a better understanding of these dementia patients' behaviors. We conducted some preliminary research and looked for some first-hand knowledge. We then made the decision to run an online survey in order to gather some important research data. The survey was conducted by sending out a Google form.

The system first creates the appropriate emotion based on the provided image using a CNN algorithm. Here, the image's URL is sent to the backend server, where the CNN model we developed is used to make the prediction. The predicted emotion is subsequently delivered as a JSON request to the front end. A customized music playlist will be created from a pre-made music library using this emotion and the user's registered age with a slideshow in the UI to keep the user engaged. I was able to do every task and get a high accuracy for the prediction, as suggested in the proposal. There are a few things that should be implemented during the testing procedure. When taken with a smartphone, the image quality degrades. Thus, it has an impact on the output's accuracy. The accuracy can be improved further than the current findings if we can capture the image with a high-quality image.

However, the current image capture result produces considerable output that the user can understand. The user will initially capture the face from the mobile device. The backend will then take in the input and gather it for processing. The CNN architecture will process the image through numerous layers in the backend before predicting the emotion.

Additionally, the system's user-friendly, minimalistic design will help the user navigate their way through the process.

Throughout the course of our research on dementia patients, several crucial factors emerged during the development and testing phases. To gain a comprehensive understanding of the dementia patient population, we initially delved into existing research. Our literature review encompassed extensive data from global dementia databases, comprising population-based studies that detailed the prevalence of dementia across different age groups. Furthermore, we gathered information on age-specific dementia prevalence rates and the total number of individuals affected by dementia within specific age brackets.

Building on this foundation, we recognized the need for firsthand insights into the experiences and challenges faced by dementia patients and their caregivers. Subsequently, we embarked on an effort to collect critical research data directly from those affected. To achieve this, we conducted an online survey tailored to the unique needs and perspectives of dementia patients and their caregivers. This survey was efficiently administered through the distribution of a user-friendly Google Form, facilitating the gathering of valuable insights and experiences from the dementia community.

Initially, implement a solution that has the capability to detect familiar faces. Then the features of the detected faces are extracted using deep neural network technologies like face encoding. Finally, computes the similarity between the face encodings using distance metrics such as Euclidean distance. A threshold value is usually set to determine whether two face encodings are considered a match. Based on the computed similarities, the system can identify known faces by finding the closest match(es) to the detected face(s) in the list of known faces.

In the testing process, there are a few things that should be implemented. The quality of the user interfaces which are suitable for elderly dementia patients.
Also, we have to check the image capturing using flash button option in low -light environment, but so far the current capturing result of faces gives a considerable output which satisfied the dementia patient. The face will be captured from the mobile device by the user initially. And then the image stored in the AWS S3 bucket. Then those stored images get downloaded inside the container storage in the AWS Elastic Container Registry. The photos will go through the several technologies such as neural network algorithms, deep neural network and then system send to the appropriate response to the frontend. Following the completion of the analysis, name and relationship will be prompted. Additionally, it gives the voice output and memory slides to recall the patient memories.

4.4. Summary of student contribution

Student: Kachchakaduwa E.U. – IT20230388
Research component: Providing a smart solution for wandering behaviour of dementia patients by inventing a tracking mechanism to track locations while establishing safe zones and analyzing their movement patterns for future predictions.

Task: This component is aligned with developing a system to track patients' locations at the time using tracking devices, making safe zones, sending notifications to caregivers when patients cross safe zones and location prediction mechanism.

Tasks completed:

- Developed the mobile application.
- Implemented the backend with google map API to provide map related features.

- Gathering information about a particular patient's movement.
- Developed most suitable location prediction models and algorithms.
- Developed all the user interfaces related to this component.

Student: Jayasinghe J.M.S.U. – IT20034740

Research component: Improving the cognitive independence and wellbeing of dementia patients by motivating them to maintain a digital audio diary

Task: This component is aligned with to develop a system to recognize voice and convert it into text and then summarize the content.

Tasks completed:

- Developed the mobile application
- Implemented the backend with fastapi to get the text summarization services by the application
- Developed text summarization models.
- Implemented proper mechanisms to recognize voice and convert it into text
- Developed all the user interfaces related to audio diary component.

Student: Hiththatiyage D.K– IT20162696

Research component: Implementing an emotion-based music player

Task: This component is aligned with to develop a system to interpret the emotion of a captured face. The inputs of this component are the image of the individual and the registered age, and the output of the predicted emotion will be displayed to the user in a printed format. Furthermore, the minimalistic UI of the application will help the patient when navigating through the application.

Tasks completed:

- Developed the mobile application
- Implemented the backend using Fast-API to get the image interpretation services by the application
- Developed image captioning and emotion detection model.
- Implemented the algorithm to extract the image content from the image
- Developed haptic feedback system in the proposed mobile application.

Student: Madhubhashini A.D.P. – IT20174576

Research component: Design a smart solution that have capability to detect patients loved ones and relatives via face recognition in a way that patient is fully independent.

Task: This component is designed to develop a face recognition system integrated into the application. Its inputs include images containing human faces, and the output will identify and provide descriptions of the recognized faces.

Tasks completed:

- Developed the mobile application
- Implemented the backend with Fast API to get the face recognition services by the application.
- Implemented the face recognition model.
- Implement text to speech library to the application to get the voice output.

5. CONCLUSION

In-depth analysis of Demcare mobile application research work led to an intelligent solution that improves the quality of life of dementia patients and helps caregivers manage their work effectively. This application was specifically designed for mild to moderate dementia patients who frequently struggle with managing day-to-day life activities. After identifying basic needs within the related medical sector, the app covers them with simplicity for both patients and caregivers. Since currently, available apps do not provide an overall solution to manage dementia patients, the implemented solution will be a turning point and let them live their normal life within society.

By thoroughly examining a variety of factors, this study makes a significant contribution to improving the cognitive independence of dementia patients. Although the system is built with simplicity, sophisticated technologies have been used to meet the audience's needs. The current work is an accurate, productive, efficient, and timely solution. The app is yet limited to the English language and future research could improve its accuracy for other languages. Additionally, future research could explore more regarding the timed needs and develop more features based on them. These potential research directions could enhance the usefulness of the proposed application for both patients and medical institutions.

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APPENDICES

Appendix A: Plagiarism report

Group Thesis

ORIGINALITY REPORT

5%	3%	2%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.coursehero.com Internet Source	1 %
2	gitlab.sliit.lk Internet Source	<1 %
3	Priyashan Sandunhetti S. H. S, Sanduni Madara P. G, Dilitha Ranjuna G. P, Prabhash K. V. A. S et al. "Digital Assistant to Aid Individuals with Print Disabilities to Interpret Printed Materials", 2022 13th International Conference on Computing Communication and Networking Technologies (ICCCNT), 2022 Publication	<1 %
4	Uyanahewa M.I.R, Jayawardana G.V.H.D, Bandara M.B.D.N, Hapugala H.A.V.V, Buddhima Attanayaka, Dasuni Nawinna. "WONGA: The Future of Personal Finance Management – A Machine Learning-Driven Approach for Predictive Analysis and Efficient Expense Tracking", 2023 4th International Conference for Emerging Technology (INCET), 2023 Publication	<1 %

Apendix 1: Plagiarism report